AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The Science of PFAS Exposure and Effects on Human Health

The Association of State and Territorial Health Officials (ASTHO) collaborated on a webinar for their members with the American Association for the Advancement of Science's Center for Scientific Evidence in Public Issues (AAAS EPI Center) on the most recent scientific evidence on human health effects of per- and polyfluoroalkyl substances (PFAS).

DECEMBER 15, 2022

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Session Summaries

DECEMBER 8, 2022

The Science of PFAS Exposure and Effects on Human Health — Session Summary

On Dec. 8, 2022, the Association of State and Territorial Health Officials (ASTHO), the American Association for the Advancement of Science's Center for Scientific Evidence in Public Issues (AAAS EPI Center), and RESOLVE co-hosted a two-hour virtual session to provide information from experts on the effects of per- and polyfluoroalkyl substances (PFAS) on human health. Invitees to this session included staff from state and territorial health agencies interested in learning more about the scientific evidence used for health assessments and guidance related to PFAS. The objectives of this session were as follows:

- Provide scientific evidence, expertise, and information related to the health effects of PFAS exposure; relevant information and resources for stakeholder audiences, including clinicians; and approaches to integrating this information into policy.
- Discuss and address state and territorial health agency staff questions related to the human health effects and outcomes from PFAS exposure.
- Support interdisciplinary, multi-agency, and cross-sector collaboration and information exchange between federal, state, and academic public health experts.
- Explore additional opportunities for sharing scientific information, resources, and experiences.

This document provides a summary of this two-hour virtual session.

Opening Comments Summary

Colleen Flaherty, deputy director for the Health and Ecological Effects Division of the Office of Science and Technology (OST)/ Office of Water (OW) at the U.S. Environmental Protection Agency (U.S. EPA), focused her opening remarks on the PFAS Strategic Roadmap, specifically the actions around water. The PFAS Strategic Roadmap was released in October 2021 and does the following:

- "Sets timelines for concrete actions from 2021 to 2024;
- Fills a critical gap in federal leadership;
- Supports states' ongoing efforts; and
- Builds on the Biden-Harris Administration's commitment to restore scientific integrity."

The Roadmap focuses on three overarching goals of U.S. EPA's PFAS actions: research, restriction, and remediation. In November 2022, U.S. EPA released the first annual report that describes work completed under the Roadmap. Upcoming Roadmap actions include setting "enforceable limits for PFOA and PFOS in drinking water," evaluating "risks of PFAS in biosolids," and addressing "PFAS in Clean Water Act permitting, analytical methods, water quality criteria, and fish advisories."

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Scientific Evidence on PFAS Exposure and Health Effects Panel Summary

PANELISTS

- **Jamie DeWitt,** Professor, East Carolina University
- **Alan Ducatman,** Professor Emeritus, West Virginia University
- **Joseph Braun,** Associate Professor, Brown University

BRIEF SUMMARY OF THE FULL PANEL

Panelists from East Carolina University, West Virginia University, and Brown University highlighted the current scientific evidence of the various effects of PFAS exposure on human health. The panelists emphasized there has been a significant increase in knowledge around this topic over the past decade. Studies have shown an association between PFAS exposure and reduced vaccine antibody response for specific vaccines. The panelists explained that this suggests that PFAS exposure can suppress immune responses and increase the risk of developing diseases. Additional research has shown that PFAS can affect the endocrine and metabolic systems, and PFAS have been linked to kidney and testicular cancer, as well as liver disease. Finally, the panelists discussed that research is ongoing to examine the impact of lifestyle factors and physical activity levels on the risk of developing specific diseases due to PFAS exposure.

Jamie DeWitt, Professor, East Carolina University

- The immune system performs many critical functions, including ensuring homeostasis and that the body has an appropriate response to physical injuries. The immune system can become dysfunctional from environmental and genetic factors. Numerous studies have examined the potential effects of PFAS on the immune system.

- In humans and animals, evidence from studies demonstrates that there can be impacts on vaccine antibody responses from PFAS exposure. There tends to be a decrease in the body's ability to mount an antibody response to specific vaccines, including the diphtheria and tetanus vaccines, associated with certain levels of PFAS exposure. This effect appears more severe in children compared to adults.
- Seeing decreases in the vaccine response indicates that the immune response is suppressed, which suggests an increased risk of developing diseases due to PFAS exposure.

Alan Ducatman, Professor Emeritus, West Virginia University

- The C8 Science Panel (2005-2013) found a "probable link" between PFAS exposure and hypercholesterolemia, thyroid disease, ulcerative colitis, testicular cancer, kidney cancer, and pregnancy-induced hypertension.
- The observed health effects of specific types of PFAS can vary. For example, PFOA is linked to the following human health effects: kidney cancer, liver toxicity, immune system toxicity, increases in cholesterol, and there is suggestive evidence of preeclampsia. PFOS exposure is linked to increased cholesterol, immune system toxicity, and pregnancy-induced hypertension with additional evidence of preeclampsia. There is also a lot of corroborative experimental evidence.
- In Dr. Ducatman's view, there is strong evidence for immunotoxicity, lipids/sterol interference, kidney cancer, birthweight impacts, and several other health effects listed on the presentation slides. Most data pertain to the historically common 'long-chain' (chain length ≥ 6 carbons) perfluoroalkyls such as PFOA and PFOS. However, other health effects, such as liver cancer, breast cancer, and thyroid disease, have suggestive, but less or conflicting evidence associating them with PFAS exposure.

Joseph Braun, Associate Professor, Brown University

- There are numerous mechanisms of PFAS-induced impacts, including bone and metabolic toxicity.
- There is a moderate level of evidence suggesting that PFAS affects heart health and can increase the risk of type two diabetes in adults. A study examining the impact of lifestyle interventions on the association between PFAS and type 2 diabetes found that the association lessened among participants receiving an intervention to increase physical activity and improve diet.
- Studies are investigating the impact of pre-natal exposure to PFAS, including developmental impacts. One study observed that gestational exposure to PFAS is associated with lower bone mineral content and bone mineral density, with the association stronger in males and cortical bone sites.

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Scientific Evidence on PFAS Exposure and Health Effects Panel Summary Discussion and Q/A with Audience

Audience Question: *With the recent decrease in values for EPA's Drinking Water Health Advisories for certain PFAS, how can we as public health professionals effectively communicate these changes to stakeholder audiences (clinicians, lawmakers, the public, etc.)? How can we communicate that these values are based on sound scientific observations?*

- Panelists brought up the example of lead in children — a safe level of exposure for lead in children has not been identified. Smoking and secondhand smoke exposure are similar — exposure is associated with lung cancer. These types of analogies might be helpful for clinical communication. Panelists also urged public health agencies to be clear when speaking about health effects — using terms like "limited" or "may" can be problematic when we know there is a health risk.

Audience Question: *How informed is the medical community (e.g., clinicians) about the following issues? If they are not yet informed about these topics, is there work underway to increase their awareness of these topics?*

- Panelists emphasized that many clinicians have not heard of PFAS or have limited knowledge about the topic. There are resources out there that can help bring clinicians up to speed, as well as help patients speak with their clinicians about PFAS. For more information, please see the resource list at the end of this document.

Audience Question: *Is biological monitoring currently a reasonable option for exposed populations? Is this a role for state government?*

- Panelists discussed how this has been asked at public meetings in the past. Currently, PFAS blood tests are not usually covered by insurance. There is guidance from the National Academies on what people who live in at-risk communities should do regarding testing. One suggestion was for concerned individuals to get clinical tests associated with the PFAS-associated health effects they are worried about, which would potentially be covered by insurance. Others suggested reviewing resources from the National Academies and the PFAS Exchange.

Incorporating Scientific Evidence into Policy Decisions Panel Summary

PANELISTS

- **Helen Goeden,** Senior Toxicologist/Risk Assessor, Minnesota Department of Health
- **Brittany Jacobs,** Office of Science and Technology/Office of Water Biologist, U.S. Environmental Protection Agency
- **Suzanne Fenton,** Reproductive Endocrinology Lead, National Institute of Environmental Health Sciences
- **Rachel Rogers,** Senior Health Scientist, Centers for Disease Control and Prevention's National Center for Environmental Health/Agency for Toxic Substances and Disease Registry
- **Kris Thayer,** Chemical and Pollutant Assessment Division Director, U.S. Environmental Protection Agency
- **Russell Thomas,** Center for Computational Toxicology and Exposure Director, U.S. Environmental Protection Agency

BRIEF SUMMARY OF THE FULL PANEL

Panelists from Minnesota, U.S. EPA, the National Institute of Environmental Health Sciences (NIEHS), and the Center for Disease Control and Prevention's National Center for Environmental Health (CDC NCEH)/Agency for Toxic Substances and Disease Registry (ATSDR) provided background on recent work they have done, and are currently doing, to assess the impact of PFAS exposure at the state and national level and how to utilize available resources to address community concerns and mitigate the risks associated with PFAS contamination.

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There are several ongoing studies to further understand the connection between PFAS exposures and health outcomes. The panelists shared several next steps based on the work they have already done and the work they plan to do. Many of the panelists discussed their ongoing assessments to identify which communities are dealing with increased exposures and the possible health impacts they are facing. Some panelists also shared resources community members can use to begin assessing the impacts on their own health.

Helen Goeden, Senior Toxicologist/Risk Assessor, Minnesota Department of Health

- PFAS contamination has been an issue in Minnesota since 2001. When developing guidance, the Minnesota Department of Health (MDH) has found that toxicokinetic information (e.g., half-life, maternal to fetus/infant transfer) are as important as toxicity information.
- Minnesota implemented statewide PFAS monitoring to identify statewide uses, releases, and environmental presence of PFAS. When chemicals are found, the public is informed and risk management decisions need to be made.
- Guidance for over 40 PFAS have been requested, nearly half of these have been detected in public water systems.
- Exposures are occurring now — telling community members to wait while more scientific research is conducted is not an option.
- MDH has a cooperative agreement with U.S. EPA and are examining U.S. EPA and National Toxicology Program Tier 1 PFAS bioactivity data as well as chemical structure/properties and toxicokinetic characteristics in hopes of providing risk context.

Brittany Jacobs, Office of Science and Technology/Office of Water Biologist, U.S. Environmental Protection Agency

- U.S. EPA's OST within OW provides information on levels that protect against adverse health effects associated with PFAS. Levels are developed under the authority of the Safe Drinking Water Act (Maximum Contaminant Level Goals, Health Advisories) and the Clean Water Act (Human Health Criteria for Ambient Water).
- U.S. EPA has a long history of assessing PFOA and PFOS under the Safe Drinking Water Act, beginning in 2009 with the provisional health advisories for PFOA and PFOS. The reference doses and health advisory values for PFOA and PFOS have decreased from 2009 to the present.
- One of the main reasons for the decrease in the present values was due to the creation of a Cross-EPA Technical Expert Team tasked with developing new assessments, which allowed for the adoption of U.S. EPA Office of Research and Development's (ORD) systematic review methods, updates to animal and human pharmacokinetic models, and quantitation of epidemiological data.

Suzanne Fenton, Reproductive Endocrinology Lead, National Institute of Environmental Health Sciences

- Lactation and environmental chemical experts have summarized existing data of PFAS in breastmilk. Studies have found that estimated PFOA and PFOS breastmilk concentrations exceed drinking water screening values at certain study sites. Infant formula also appears to be compromised.
- Need to start thinking in a precautionary way regarding PFAS so we can ensure our children are being fed in a healthy way and people can breastfeed safely if they choose to.

Rachel Rogers, Senior Health Scientist, Centers for Disease Control and Prevention's National Center for Environmental Health/Agency for Toxic Substances and Disease Registry

- CDC NCEH/ATSDR's goal is to better understand how and where PFAS exposures are occurring, to understand the relationship between PFAS exposure and the risk of health effects, and to identify and implement strategies to prevent exposure in the future.
- Recent findings from ATSDR's Exposure Assessment studies show PFHxS blood levels were higher in communities near military bases compared to the rest of the country. Data strongly suggested that the elevated blood levels were due to drinking water exposure.
- The goal of the ongoing multisite health studies is to look at the relationship between PFAS exposures and observed health outcomes.
- PFAS Blood Estimation Tool — this tool is intended for community members who have consumed PFAS in drinking water. It is not intended to replace individual PFAS blood sampling but can hopefully help concerned individuals estimate what their individual PFAS levels may be.

Kris Thayer, Chemical and Pollutant Assessment Division Director, U.S. Environmental Protection Agency

- U.S. EPA's ORD has done several PFAS assessments. A few of them are complete and some are ongoing.
- Systematic evidence maps use systematic review methods to identify and summarize animal bioassay and epidemiological evidence for large numbers of PFAS. U.S. EPA's ORD is looking to make information available to the community in a shareable, updateable, and interactive way. These will be used to inform other work being done at U.S. EPA.

Russell Thomas, Center for Computational Toxicology and Exposure Director, U.S. Environmental Protection Agency

- The focus of this research is to create an approach for grouping PFAS based on similarity in structure and properties relevant to chemical risk assessment, given the large number of PFAS to which exposures may have occurred.

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- These groupings could serve as the basis for both identifying PFAS chemicals for testing, as well as allowing U.S. EPA to establish toxicity levels within the identified groups.
- As a result, U.S. EPA has developed initial structure-based PFAS categories, identified PFAS categories with data gaps, and refined PFAS categories using mechanistic, toxicokinetic, and in vivo testing data.

Incorporating Scientific Evidence into Policy Decisions – Discussion and Q/A with Audience

Audience Question: *States are often asked to act quickly and may not be able to wait for the results of lengthy human or animal toxicity studies. Can anyone on the panel talk a bit more about current efforts to utilize non-animal/non-human toxicity data in PFAS risk assessment? What is the current state of relying on non-traditional toxicity testing method results for PFAS risk assessment in your work?*

- Panelists talked about using different methods to inform guidance, such as using shorter testing methods and comparing those data to longer term studies that have already been done. In Minnesota, surrogates have been used for some of the compounds.

Audience Question: *Is ATSDR planning to publish technical support documentation that explains the assumptions used in the PFAS Blood Level Estimation Tool? Did ATSDR compare results from the tool to the data collected from the PFAS Exposure Assessments? How did it do?*

- ATSDR is planning to release technical information regarding the tool. Additionally, the tool performed well in comparisons with the PFAS Exposure Assessments.

Additional Resources for Attendees

ATSDR: ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for PFAS

ATSDR: Map of ATSDR PFAS Sites

ATSDR: PFAS Blood Level Estimation Tool

ATSDR: PFAS Exposure Assessment Sites

Environmental Health Perspectives: Bayesian Estimation of Human Population Toxicokinetics of PFOA, PFOS, PFHxS, and PFNA from Studies of Contaminated Drinking Water

Environmental Health Perspectives: Systematic Evidence Map for Over One Hundred and Fifty Per- and Polyfluoroalkyl Substances (PFAS)

Green Science Policy Institute: PFAS

Green Science Policy Institute: PFAS Central

Minnesota Department of Health: Per- and Polyfluoroalkyl Substances (PFAS)

National Academies of Sciences, Engineering, and Medicine: Guidance on PFAS Testing and Health Outcomes

North Carolina State University: PFAS at the Tap Infographic

PFAS REACH: PFAS Exposure: Information for patients and guidance for clinicians to inform patient and clinician decision making

PFAS Tox Database

Silent Spring Institute: PFAS Exchange

U.S. EPA: Drinking Water Health Advisories for PFOA and PFOS

U.S. EPA: Drinking Water Health Advisories (HAs)

U.S. EPA: PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024