

## Opinion: Challenges and Safeguards - Filling the Gaps in Toxicological Research of Heavy Metals

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Anthropogenic sources of heavy metals from a wide array of domestic and international sources in industry, technology, medicine, agricultural, technological, have long raised concerns of their effects on human health and environmental health. Heavy metals are widely accepted as highly toxic, hence their high ranking as chemical of public concern. Yet much of what we know in the scientific community regarding are sole source or exposures to one or two combined heavy metals. Researchers are working diligently trying to fill in the gaps for the determination of toxic mode of action, chronic effects of trace exposures to heavy metals, methods to diagnose disease caused by environmental factors. The complexity lies in the fact that the laboratory bench cannot effectively simulate real world exposures. While technology and research methods continue to evolve, many of these new assays still struggle to characterize the toxicity of more than one heavy metal. We must continue to develop and test new assays and develop methodologies that pull from multiple assays in order to create the most complete and accurate toxicological characterizations. As scientists, we are obligated to continue to conduct meaningful research that will better help toxicologists more accurately illustrate the acute and chronic health effects from chemical mixtures. Heavy metals are

already classified as known or probably carcinogens and are known systemic toxicants that cause damage to multiple organs. Determining the mechanisms of systemic and targeted toxicity are critical in order to make risk assessments and set environmental health standards that are as accurate as possible. Heavy metal toxicity depends on multiple physicochemical and biological factors, including chemistry, dose, and concentration, duration of exposure as well as genetics, age, gender, nutritional status, health status, and route of exposure. It is incumbent on research investigators, that we not only work to make accurate assessments, but strive to ensure that bias does not enter into our findings by rigorous documentation, clear statements of gaps in findings and critical future work, peer review and collaboration. This will not only safeguard the integrity of our findings but will bolster our data and conclusions against skeptics. As our exposures to heavy metals remains ever present in our environment, so too will the public interest in the long-term effects on our health.

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