

# Use Information and Data to Support Health-Protective Policies and Practices

## Policy Paper #4 for the LOUISVILLE CHARTER

### Authored by:

Jennifer Sass, Natural Resources Defense Council

Eve Gartner, Earthjustice

Sonya Lunder, Natural Resources Defense Council

Ted Schettler, Science and Environmental Health Network

Veena Singla, University of California San Francisco

Steve Taylor, Coming Clean

2026



# TABLE OF CONTENTS

<b>SUMMARY</b>	<b>3</b>
<b>INTRODUCTION: CHEMICAL MANUFACTURING AND USE PRACTICES CAUSE HARM</b>	<b>4</b>
<b>USING SCIENTIFIC DATA TO SUPPORT HEALTH PROTECTIVE POLICIES AND PRACTICES</b>	<b>7</b>
<b>A. Act quickly with existing data and information that identifies hazardous chemicals.</b>	<b>8</b>
Include knowledge from communities facing health hazards	9
Use public data	9
Account for cumulative exposures and impacts	10
Use established methods to fill data gaps	11
Adopt systematic review frameworks	12
Use Predictive Toxicology to Improve Health Protections	12
Utilize all relevant science, not just regulatory toxicology	13
<b>B. Evaluate and regulate chemicals by classes rather than one chemical at a time.</b>	<b>14</b>
<b>C. Include and address additional impacts across chemical life cycles.</b>	<b>15</b>
<b>RECOMMENDATIONS</b>	<b>17</b>
• Chemical hazard assessment, not risk assessment, should form the basis for chemical regulation.	
• Chemical hazard evaluations should use a systematic review framework.	
• Identify full chemical hazards over the life cycle and fill data gaps using existing information.	
• Robust evidence of harm should trigger protective actions to quickly end production and use of hazardous chemicals and chemical classes; data gaps and uncertainty should not be weaponized to further delay environmental health protections.	
• Chemical policies should be accountable for reducing disparities in the most impacted populations.	
<b>Conclusion</b>	<b>18</b>

# SUMMARY

---

This policy paper, a supplement to the Louisville Charter for Safer Chemicals, addresses the urgent need to transform chemical management systems to protect human health and the environment from petrochemical-based products and their toxic impacts. Chemical production and use cause widespread harm, from fossil fuel extraction to product disposal, disproportionately affecting workers, low-income communities, people of color, and Indigenous populations. These groups face cumulative exposures to hazardous chemicals, compounding social and economic inequities and health disparities such as cancer, respiratory diseases, and developmental disorders.

**Current U.S. regulations rely heavily on a risk-based approach, which typically evaluates one chemical at a time and often delays action due to data gaps and uncertainty. This paradigm has failed to protect public health,** leaving dangerous chemicals such as asbestos, PFAS, and endocrine disruptors in use for decades. Industry tactics exploit scientific uncertainty to obstruct regulation, perpetuating harm and environmental injustice.

**The paper calls for using existing scientific data to take protective action without waiting for exhaustive risk assessments. It recommends evaluating chemicals by classes rather than individually, incorporating community knowledge and cumulative impact assessments, and considering hazards across the entire chemical lifecycle.** Regulatory decisions should utilize systematic review frameworks and all available data sources—including public databases and real-world evidence—to strengthen protections.

Key principles include:

- Acting quickly with existing data to eliminate hazardous chemicals.
- Regulating chemical classes to reduce the likelihood of “regrettable substitutions.”
- Addressing full life-cycle impacts of chemical production, use, and disposal.

**The paper concludes that we have enough evidence to act now.** A shift to hazard-based regulation, accountability to impacted communities, and transparent, science-driven decision-making is essential for protecting public health, reducing disparities, preventing irreversible ecological damage, and creating a future free from toxic chemicals.

# INTRODUCTION: CHEMICAL MANUFACTURING AND USE PRACTICES CAUSE HARM

**“Risk assessment was never really intended to generate useful information for regulators.. From a public health perspective, it has failed in every way that matters.”**

There are hundreds of thousands of chemicals registered for industrial and commercial use. Many are petrochemicals made from fossil fuels. For example, petrochemical plastics can be made flexible, durable, or clear with additional petrochemicals.<sup>1</sup> Conventional pesticides and fertilizers are petrochemical-based, making industrial farming both toxic and unsustainable. Yet, inadequate attention is given to harm to people, the environment, and the climate caused by these chemicals. Effects can occur throughout the lifecycle, from fossil fuel extraction, transportation, and processing to product manufacturing, use and disposal. For example, conventional insecticides and fertilizers poison farmworkers, soil and waterways, wildlife, and food crops. Petrochemicals and the pollution generated from their production, use, and disposal is linked with health impacts such as elevated risk of disease and premature death, health disparities, staggering economic costs, and lasting ecosystem destruction.<sup>2</sup>

People can be exposed in myriad ways throughout the lifecycle of toxic chemicals: through pollution such as chemical contamination in air, food and drinking water; from hazardous chemicals intentionally added to formulate cosmetics and personal care products.

Human suffering from toxic chemicals has fallen hardest on workers (especially workers that are temporary, migrant, contract, or non-unionized), people of color, Tribes and Indigenous peoples, fenceline and low-income communities, communities and countries undergoing industrialization, and

developing infants and children.<sup>3</sup> Racial discrimination, economic inequities, and political barriers contribute to and perpetuate such patterns.<sup>4</sup>

Toxic ‘legacy’ sites, such as contaminated former industrial areas, military facilities, waste disposal sites, and ‘Superfund’ sites are disproportionately located in low-income and communities of color.<sup>5</sup> Large scale chemical storage and processing facilities are often densely packed into these communities. They pose health risks from chemical exposures, and safety risks such as leaks, explosions, and fires.<sup>6</sup> Many of these chemical manufacturing, storage or processing facilities are disproportionately located in environmental justice communities prone to extreme weather like hurricanes and flooding that are exacerbated by climate change. This poses the threat of a “double disaster” for those communities.<sup>7</sup> In the U.S., over 130 million people – overwhelmingly low income and people of color - live in the chemical disaster ‘vulnerability zone’ of one or more of the roughly 3,430 facilities in several common industries that produce, store and use highly hazardous chemicals.<sup>8</sup> Additional exposure to fossil fuel combustion results from heavy vehicle traffic in and around these industrial areas.

Concerns are not limited to communities adjacent to chemical releases or storage. Certain toxic and persistent chemicals travel on air currents or are transported long distances from such facilities. They accumulate in food sources and food chains. They create hazards for communities far from the original sources. Many of these are Persistent Organic

Pollutants (POPs) like dioxin and the pesticide DDT (dichloro-diphenyl-trichloroethane) made infamous in Rachel Carson's book 'Silent Spring'. The POP chemicals concentrate in Arctic and Antarctic polar regions, poisoning sea mammals and other wildlife that are critical food sources for Arctic Indigenous peoples and other circumpolar communities.<sup>9</sup>

Many of the health risks from petrochemicals are chronic, with the effects emerging and worsening over time. For example, disparities in exposure to harmful chemicals based on a person's race and income result in higher-than-average rates of autoimmune diseases,<sup>10</sup> cardiovascular disease and hypertension,<sup>11</sup> diabetes,<sup>12</sup> asthma and chronic lung ailments,<sup>13</sup> and cancer<sup>14</sup>. The result of these physical ailments includes increased risk of having a baby with health problems,<sup>15</sup> reduced overall quality of life, compromised ability to work and support a family, and high risk of premature death.<sup>16</sup> Petrochemical-based agrochemicals have led to poisoning of well water with nitrates, which when used to prepare infant formula is a well-known risk for 'blue baby syndrome' that can cause coma or death if left untreated.<sup>17</sup>

As detailed in the Louisville Charter for Safer Chemicals: "The risks and impacts caused by the pollutants, both individually and when combined with each other and social vulnerabilities, are called cumulative impacts. Cumulative impacts are almost certainly one reason our nation suffers from persistent health disparities and inequities that are rooted in race and income."<sup>18</sup> Historical and ongoing systemic racism and classism work to deepen and widen these disparities.<sup>19</sup>

Scientists' calls for chemical bans, replacement of hazardous materials with safer alternative products and processes, and the installation of pollution controls have not led to enough government action, whether due to lack of resources, lack of authority, lack of will, industry capture, or myriad other excus-

es.<sup>20</sup> For example, cancer-causing chemicals formaldehyde and styrene have undergone assessment and reassessment for over thirty-plus years, yet continue in widespread use in consumer, commercial and industrial uses despite their well-documented hazards.<sup>21</sup>

Part of the problem is that most chemical management frameworks take a risk-based approach to chemical regulation, which fails to protect people and the planet in many ways. As law scholar William Boyd wrote in his 2024 article on the Failures of Chemical Regulation: "Although risk assessment has often been understood as a largely technical, scientific exercise that provides the basic facts needed for the more value-laden exercise of risk management (itself cast as an exercise in cost-benefit analysis), the history of risk assessment makes clear that it has operated first and foremost as a political technology intended to discipline agencies and constrain their ability to solve complex problems, rather than as a tool to generate useful information about the world. Indeed, from the beginning, risk assessment was pushed by industry as a way of ensuring that no regulation would proceed until we determined exactly how many workers or how many people might suffer a particular harm from a certain level of exposure.... Risk assessment, in short, was never really intended to generate useful information for regulators. Rather, it was directed almost from the start at disciplining agencies and replacing expert judgment with a more formal, rule-governed rationality that saddled these agencies with impossible analytical demands, which in turn created seemingly endless opportunities for contestation and delay. From that vantage, risk assessment has been wildly successful. But from a public health perspective, it has failed in every way that matters."<sup>22</sup>

Among its many problems, a risk-based paradigm generally addresses one chemical at a time (if at all), ignores cumulative impacts, and requires significant

amounts of data on both the hazards and exposures of individual chemicals. Existing chemicals that were already registered with EPA when the Toxic Substances Control Act (TSCA) was passed in 1976 (approximately 62,000) were “grandfathered” - essentially exempted from investigation or regulation. And in the first 40 years after the passage of TSCA, only about 200 chemicals were assessed for safety, and EPA was able to restrict less than 10.<sup>23</sup> Even asbestos could not be fully banned under TSCA. With over 350,000 chemicals registered globally for production and use, and little empirical testing data on health and environmental effects for the vast majority of these chemicals, it can appear that we lack the data needed for regulatory action.<sup>24</sup>

However, what we now understand is that we have more than enough information on many types of hazardous chemicals to limit or eliminate their use, and do not need the type of comprehensive data required for a risk assessment to take protective action. For example, as detailed in the Louisville Charter for Safer Chemicals Policy Paper supporting Plank #3 by Beverly Thorpe, “Require Safer Substitutes and Solutions for a Non-Toxic Economy,” just seven petrochemicals are the building blocks for more than 90% of downstream organic chemical production, including tens of thousands of chemical products. These seven chemicals are: methanol; olefins—ethylene, propylene, and butadiene; and aromatics—benzene, toluene, and xylene. Most of these “platform chemicals” have high intrinsic hazards and perpetuate these hazards throughout the value chain, so steps should be taken to limit their use and require substitutions as protective action.

Further, there is mounting evidence that synthetic chemicals, and the products made from them like plastics and pesticides, are threatening the integrity of Earth systems that humanity depends upon to thrive.<sup>25</sup> Scientists are raising the alarm that we have exceeded the “planetary boundary” for synthetic

chemicals, and that we must reduce the number and volume of such chemicals that we are producing and using.<sup>26</sup>

Unfortunately, whether a chemical’s hazards are well-characterized or not, the reality is that health protective regulations and policies, if they come at all, are adopted only after years or decades of widespread use, human exposures, and environmental releases. **Protections are always too late for those whose exposures have led to illnesses and deaths. The uncertainty that is part of science and data is weaponized to force delays, thwart regulations, and deny protections.** This is detailed in David Michaels’ 2020 book, *The Triumph of Doubt: Dark Money and the Science of Deception*, summed up in a review in *Nature* magazine: “The principles of scientific inquiry involve testing a hypothesis by exploring uncertainty around it until there is a sufficient weight of evidence to reach a reasonable conclusion. Proof can be much longer in coming, and consensus still longer. The product-defense industry subverts these principles, weaponizing the uncertainty inherent in the process. Its tricks include inflating dissent where little remains, cherry-picking data, reanalyzing results to reach different conclusions and hiring people prepared to rig methodologies to produce funders’ desired results.”<sup>27</sup>

While there have been many innovative methods developed to fill data gaps, the information is not efficiently analyzed to provide timely and protective guidance to regulatory agencies. To interrupt this pattern, in this paper we discuss four critical aspects of how to better use data to advance timely, health protective actions that safeguard high-risk communities and redress long standing systemic racial injustices and protect people and the planet.

# USING SCIENTIFIC DATA TO SUPPORT HEALTH PROTECTIVE POLICIES AND PRACTICES

To transform the chemical industry to one that no longer threatens people's health or the planet – consistent with the Louisville Charter – **regulatory agencies, lawmakers, and industry must start using science to support the phase-out of toxic substances and stop using science as a weapon to delay action and deny protections.** This requires that scientific data – including epidemiology, rodent toxicology, cellular and mechanistic information, poisoning reports, spill and release incident data, fenceline monitoring, and community data including 'bucket brigade' air monitoring, health surveys and lived experience - all be used in the public interest. When decision-makers identify hazardous chemicals, they should quickly eliminate them from production and use, and require the use of safer alternatives, consistent with EPA's commitment to the Principles of Green Chemistry and Green Engineering,<sup>28</sup> and with the Louisville Charter for Safer Chemicals on safer substitutes and solutions for a non-toxic economy.<sup>29</sup>

As mentioned above, the U.S. chemical management framework employs a risk-based approach (risk assessment), which is failing to protect communities in myriad ways. For example, risk-based approaches generally assess one chemical or one source at a time and don't account for the reality of multiple exposures. This approach that deems a single chemical or source "safe" or "low risk," allows the accumulation of multiple chemical and source exposures, resulting in cumulative exposures and impacts.<sup>30</sup> Additionally, the regulatory science used in risk assessment is often outdated and inconsistent with our current understanding of human variability, vulnerability, susceptibility, and exposure—resulting in policy decisions that leave communities unprotected and over-exposed to toxic pollution and chemicals.<sup>31</sup> For these reasons and many others, the Louisville

Charter for Safer Chemicals calls for using scientific data to support health protective policies and practices within a hazard-based approach to chemicals management, and recommends moving away from a risk-based approach wherever possible.

**Equally important is the need for chemicals management to be grounded in the experiences of the most impacted communities and workers, and ensure strong protections that end the sacrifice of some people and communities to protect the interests of the chemical industry.** Development and implementation of national, state, and local laws and regulations must:

- Meaningfully involve and be accountable to those most affected by chemical hazards and exposures;
- Reflect the real-life experiences and knowledge of these communities and individuals;
- Ensure that hazards and harms are not shifted from some communities to others (including to other countries);
- Quickly deliver strong health protections and exposure reductions, and establish the basis for achieving the Louisville Charter vision of a chemical industry that does no harm to people or the planet.

However, we recognize that this policy transition will take time. In the meantime, some of our recommendations below can be applied in either a hazard or risk-based approach, and there are also important improvements that can be made to update risk assessment science to better protect communities. We are noting some of these needs within a risk-based framework even though it is not our main focus.

The following principles should be applied to use scientific information to support health-protective policies and practices that ensure the health and safety of all people, communities, and the environment:

## A. Act quickly with existing data and information that identifies hazardous chemicals.

## B. Evaluate and regulate chemicals by classes rather than one chemical at a time.

## C. Include and address additional impacts across chemical life cycles.

Each principle is described in more detail below. In summary, since the Louisville Charter for Safer Chemicals was first published in 2004, and updated in 2021, the landscape of data, data evaluation, and data integration has been dramatically altered. New testing and modeling methods provide a vast amount of information on chemicals, but government practice does not consistently translate scientific evidence into chemical restrictions and health protections. The political and financial influence of the petrochemical industry continues to distort chemical assessments and regulatory decisions, blocking the use of robust scientific evidence that already exists to protect people and the environment. And the health and safety of the most impacted communities and workers continues to be sacrificed. All of this needs to change.

In any chemical assessment and regulatory framework, transparency, equity, and independent decision-making are critical. Funding sources and research methodologies must be fully disclosed for all data and evidence relied on, and studies funded by the regulated industries should not be considered as independent or reliable unless they can be independently verified. Decisions about chemical regulation must include the most affected workers and communities in the decision-making processes. Policies and practices must protect all people and communities, and not shift impacts or burdens.

## A. Act quickly with existing data and information that identifies hazardous chemicals.

In 2004, the original Louisville Charter included the principle of ‘no data, no market’ to address the appalling lack of publicly available hazard and exposure information about most chemicals already on the market. Largely due to advocacy around the principle of ‘No data, no market’, the EU adopted a comprehensive chemical regulation in 2007, Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), and almost a decade later, in 2016, the U.S. amended its **Toxic Substances Control Act (TSCA)**. Both REACH and TSCA obligated authorities to identify risks, restrict uses of substances that cannot be mitigated, and require safer substitutes. Both laws also require chemical manufacturers to submit information about their chemicals to regulators on a regular basis, and EPA has broad power to order manufacturers to develop new data. This has meant having to contend with how to generate and evaluate large amounts of data. Unfortunately, the problem is that more information has not necessarily led to more regulatory restrictions or more health protections.

## **We have enough data and evidence to act on the many classes of known hazardous chemicals now.**

There are many ways that EPA, other agencies, and regulators could strengthen chemical regulations and increase public protections by making better use of existing data and information. Below, we discuss a number of ways to do this.

### *Include knowledge from communities facing health hazards*

Scientific research and chemical policies should be aligned with the priorities of populations most exposed to, susceptible to, or harmed by hazardous chemicals. These populations include but are not limited to: fenceline communities; first responders; workers and labor representatives; and those with limited access to health care, safe housing, and healthy food and water. Additional community members that can provide critical real-world information include health care providers, teachers and parents, and small business leaders. Communities may be concerned with process: that is, *how* research is conducted, or how policies are developed or implemented, and are communities involved? Communities may also be concerned with the substantive focus of research or policy: that is, what questions is the research trying to answer, or what problems is the policy trying to solve. Researchers and decision-makers should therefore consider community engagement related to both the substance and process of their work.

Impacted communities should have, at minimum, meaningful engagement in the design, implementation and evaluation of research, programs and policies. The International Association for Public Participation defines different categories of public participation, ranging from “inform” to “empower.”<sup>32</sup> The Principles of Environmental Justice state that

“Environmental Justice demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation.”<sup>33</sup>

Agencies and researchers should strive to empower impacted communities to leadership in the decisions that affect them.

Research and policies that are informed by those people who are most impacted have a better chance of producing outcomes that will create meaningful harm and hazard reductions. Local and community knowledge can identify critical research questions, help shape study design, guide data collection, and inform the interpretation of results. For example, there is a wealth of information demonstrating implementation of both traditional, Indigenous, and newer, innovative agroecological practices that produce ample, healthy food while helping mitigate climate change and supporting vibrant rural communities with no use of synthetic pesticides and fertilizers.<sup>34</sup>

Guidance from environmental justice communities, fenceline communities, Indigenous communities, and constituencies like farmworkers and chemical facility workers that are most exposed and disproportionately impacted, can shape policies and practices that are more likely to result in meaningful environmental and health protections. In contrast, failing to include local knowledge may unwittingly lead to uninformed or inaccurate research results and meaningless or even harmful conclusions and recommendations.<sup>35</sup>

### *Use public data*

Making better use of the tremendous volume of publicly available data and information can help reduce uncertainties, fill in data gaps, populate and ground-truth models, and inform the grouping of chemicals into classes. For example, medical case reports of poisoning and chemical illness can

provide important information on health effects and also on real-world exposure scenarios. Information on wildlife kills and other impacts can do the same for ecosystem effects.<sup>36</sup> Agencies are not currently utilizing this full range of publicly available information to inform decisions. For example, researchers were able to identify a far greater number of fatalities linked to the toxic organohalogen solvent methylene chloride than EPA's original assessment by utilizing data from poison control centers and legal cases, amongst other sources.<sup>37</sup>

Other valuable chemical use and release data exists in federal and state agency databases, such as EPA's Toxics Release Inventory (TRI), National Emissions Inventory (NEI), data from discharge monitoring reports, hazardous waste reporting, Clean Air Act violations, and more—with some of this information compiled in EPA's Environmental Compliance and History Online (ECHO).<sup>38</sup> The TRI is a public resource of about 770 chemicals for which industry must report volume of chemical releases to air, water and land as well as volumes and methods of waste management.<sup>39</sup> It is a powerful database, updated annually, for which EPA has made considerable progress in making the data accessible in usable formats, which should be better utilized in decision-making. For example, TRI data can be utilized to understand the nature and locations where cumulative burdens are faced by communities.<sup>40</sup> TRI could be strengthened by adding additional chemicals, requiring all polluting industries to report, closing reporting loopholes, and adding verification mechanisms for what is largely industry self-reporting. Reports of chemical facility spills, explosions and other unintentional chemical releases are tracked by the Coalition to Prevent Chemical Disasters, on its website of public information.<sup>41</sup>

Wildlife and human health scientists can use poisoning incident data to characterize the toxicity of chemicals and chemical mixtures. For example, pesticide regulations are routinely informed by

reports of fish kills, bird kills and human pesticide poisonings. Regulators can use these public data sources to evaluate existing regulatory programs, support enforcement actions, and inform future regulations. Exposure models and predictive toxicology approaches can be populated and validated against real-world information provided by many public databases.

In summary, information that is publicly available should be used by regulatory agencies and others to evaluate the real-world health and safety impacts of chemicals throughout their lifecycle, to evaluate chemical hazards including across classes of chemicals, and to inform regulatory decisions to prevent harm.

## *Account for cumulative exposures and impacts*

Much of the failure of existing chemical risk assessment is its narrow and unrealistic evaluation of single chemical and single source exposures, with total disregard of the lived reality for many workers and communities. Failure to account for the totality of chemical exposures, whether from all nearby polluting facilities or from bioaccumulated chemicals, can underestimate harm from even worst-case scenario predictions. As detailed in the Louisville Charter for Safer Chemicals Policy Brief supporting Plank #2 by Drs. Ana Baptista and Nicky Sheats, “Cumulative impacts are almost certainly one reason our nation suffers from persistent health disparities and inequities that are rooted in race and income.”<sup>42</sup> Nonetheless, chemical evaluations largely fail to incorporate current science on the cumulative toll of environmental and social threats including racism and poverty, resulting in outcomes that do not recognize, and thus perpetuate, disproportionate impacts on communities most in need of protections.

Epidemiologic studies can provide critical real-world information about chemical hazards, exposures and health outcomes across communities and populations. Because epidemiology studies patterns of health and disease in a defined population, it accounts for the total exposure environment, including cumulative exposures from multiple nearby industrial facilities, chemical exposures from household and consumer products, dietary exposures from chemical contaminants in food and water, and any occupational exposures. Epidemiology is the study of real people living in the real world; it therefore offers a tremendously important contribution to chemical evaluations. For example, researchers reviewing epidemiological data on phthalates concluded that current risk-based reference doses were not sufficiently protective.<sup>43</sup> Epidemiologic data can inform both hazard characterization and risk assessment.<sup>44</sup> Nonetheless, like all scientific disciplines, it can be misused by those with financial conflicts of interest to negate or underestimate risks, deny harm, and delay regulation.<sup>45</sup> This may be avoidable by using established systematic review frameworks to evaluate data and understand such potential weaknesses and biases (see systematic review section).

## *Use established methods to fill data gaps*

Incomplete data, or uncertainty in data, is too often used as a weapon to justify delaying chemical restrictions or regulations while calling for more research. But we have well-established, science-based methods and tools which regulatory agencies and others should utilize to fill data gaps, reduce uncertainty, and move forward with timely protective actions. For example, regulatory agencies routinely use methods which predict the properties of a chemical by comparing it to similar chemicals - called 'read-across' or 'category-based' approaches - to extrapolate information from chemicals that

are better characterized to related chemicals that are poorly characterized.<sup>46</sup> The better-known chemicals are used to predict the health and safety concerns for the lesser-known chemicals. These methods and models have been used for many years, and have science, validation, and confidence to support them.

When information is missing or unreliable, decision-makers should use scientifically-based adjustment factors, including uncertainty factors (UFs) that will protect health to improve the timeliness of the chemical assessment and decision-making process. Historically, three types of UFs had been used in chemical risk assessment: to account for limitations in the data (data uncertainty); to account for extrapolations from rodent studies to human populations (interspecies extrapolation); and to account for variations within human populations (intraspecies variability). However, there is now significant science indicating both that the standard magnitudes of these traditional UFs are often not sufficient, and that in many cases additional protective factors are needed to account for harms at low doses, increased susceptibility across life stages, and other impacts.<sup>47</sup> Agencies should not be permitted to depart from health-protective assumptions or reduce UFs, without explaining how their decision meets scientifically based criteria, which should be established in advance through a transparent process.

Similarly, one should approach with care any efforts to declare the safety of chemicals. For example, the Threshold of Toxicological Concern (TTC) is a tool that can be used to prioritize efforts to focus on analyzing chemicals that may cause the greatest health burdens, due to higher levels of exposure. But such prioritization tools should not be used as the sole basis to classify a chemical as low or no toxicity.

Most importantly, where uncertainties remain and data gaps cannot be filled, regulatory agencies and decision-makers must not treat chemicals as safe.

Gaps in toxicity data should not delay adopting and implementing policies and practices that protect farmworkers, those living on the fenceline of hazardous chemical industries, and other environmental justice communities—often low-wealth and communities of color— from breathing, drinking, and ingesting chemicals whose safety is at best questionable.<sup>48</sup> When scientists and regulators fail to make protective decisions based on the available data, these communities suffer the greatest harm.

## *Adopt systematic review frameworks*

The use of established systematic review frameworks that meet scientific best practices can support regulatory agencies in increasing transparency and consistency, and reducing bias, in chemical evaluations.<sup>49</sup> Systematic reviews provide a consistent and transparent framework for formulating research questions, conducting literature reviews, and evaluating the evidence.<sup>50</sup> Importantly, the transparency and documentation of a systematic review can help identify points of divergence when the same body of evidence is used by different entities to support divergent conclusions.<sup>51</sup>

Within a systematic review, individual studies and data streams are evaluated for their strengths and potential risks of bias, such as whether study authors or sponsors have financial conflicts of interest. This evaluation can be applied to epidemiological studies, as mentioned above, so that strong, conflict-free studies may be identified as more reliable sources of information. This evaluation can also be applied to data from cell-based and rodent toxicology studies, discussed below.

Systematic review frameworks that have undergone peer-review and public input include: the IARC Monographs Preamble 2019<sup>52</sup>; University of California San Francisco's Navigation Guide (UCSF

Navigation Guide)<sup>53</sup>; the U.S. National Toxicology Program's Report on Carcinogens Handbook<sup>54</sup> and its Office of Health Assessment and Translation Systematic Review methodology (National Institute of Environmental Health Sciences [NIEHS] NTP-OHAT)<sup>55</sup>; the Systematic Review and Integrated Assessment of endocrine disrupting chemicals (SYRINA)<sup>56</sup>; and World Health Organization and International Labour Organization (WHO-ILO) systematic review methods to estimate the work-related burden of disease and injury<sup>57</sup>. Use of these frameworks will improve understanding of environmental health evidence, which can in turn help support more timely and transparent decision-making.<sup>58</sup>

## *Use Predictive Toxicology to Improve Health Protections*

Data is lacking regarding the effect of exposure to multiple chemicals such as in mixtures and product formulations, or cumulative exposures from multiple sources such as contaminated air, water, and food. The Louisville Charter for Safer Chemicals identifies this as a major problem with the chemical industry: “chemicals proliferate on the market with little to no health data and few regulatory requirements for chemical producers or downstream users of chemicals to fill much needed data gaps and/or demonstrate safety prior to market.”<sup>59</sup>

Over the last several decades, predictive toxicology has emerged as a strategy to reduce reliance on rodent testing. These approaches include cell-based in vitro test methods and computational methods, together called ‘**New Approach Methods**, or **NAMs**. NAMs have shown utility for acute and biologically simpler endpoints such as skin and eye irritation and sensitivity, and some are incorporated into regulatory frameworks. However, they may never be able to predict complex multi-system

effects such as for immune diseases, learning and memory deficits, and developmental problems.<sup>60,61</sup> Importantly, negative (i.e. null) results from predictive toxicology methods including NAMs should not be interpreted as affirmative evidence of safety; this applies to hazard information more generally.

Used appropriately, information from predictive toxicology methods should complement—not replace—available data and relevant information, particularly for complex health endpoints. Regulatory use of predictive toxicology methods should prioritize transparency, independent scientific review, and environmental health protection.

## *Utilize all relevant science, not just regulatory toxicology*

A main limitation in chemical hazard evaluations is that they largely, sometimes solely, rely on the regulatory toxicity studies sponsored by the chemical manufacturer and submitted to government agencies for the purpose of gaining market approval, such as studies required for chemical registration under the U.S. pesticide law, FIFRA (Federal Insecticide Fungicide and Rodenticide Act), REACH in the EU, or a new chemical application under TSCA in the U.S. Regulatory studies accepted by both the U.S. and EU are those that follow certain standard methods, called ‘Guideline studies’, and are conducted according to Principles of Good Laboratory Practices (GLP). However, Guideline studies and GLP are not an assurance of either scientific quality or relevance. Guideline studies are simply those that adhere to pre-set test methods, often outdated, inflexible, and incapable of detecting low dose effects or complex multi-system effects because these outcomes are not assessed - such as neurobehavioral, learning, or reproductive problems. GLP are requirements imposed on industry test labs after being found fabricating results and producing

fraudulent reports.<sup>62</sup> GLP addresses study documentation – things like keeping lab notes in pen instead of pencil, and in a bound book instead of a binder where pages can be added or removed – to help ensure that the conduct of the study is accurately reported.

Neither GLP nor pre-set study guidelines can address whether the most relevant study question is asked, or whether the most appropriate study method is applied.<sup>63</sup> In contrast, non-regulatory studies include those conducted at academic institutions that are free from financial conflicts of interest. The recent CLARITY-BPA collaboration, in which academic and regulatory studies were compared, determined that only the academic studies – which are innovative, cutting edge, and often exploratory – could reliably detect low dose effects of Bisphenol-A exposures.<sup>64</sup> Evaluating studies within a systematic review framework mentioned above can help identify weaknesses in methods and study design.

Another reason that government agencies should not rely solely on regulatory toxicity studies to make hazard determinations is that these studies are largely sponsored by the chemical manufacturer for the purposes of gaining regulatory approval of its products, and the sponsorship poses a direct financial conflict. Evidence shows that industry-sponsored regulatory toxicology is more likely to report findings favorable to the sponsor, downplaying potential hazards; some documented examples include PFOA, bisphenol A, hexavalent chromium, the insecticide chlorpyrifos,<sup>65</sup> and the herbicide glyphosate.<sup>66</sup> Over-reliance on industry sponsored studies is likely to bias regulatory decisions that increase the sales and uses of a chemical while underestimating its toxicity or other hazards.<sup>67</sup> Full disclosure of study sponsorship is necessary, but not sufficient to manage financial conflicts. In addition to enforceable disclosure policies, because industry-sponsored studies may be biased to underestimate toxicity, they must be evaluated

within a systematic review framework that considers financial conflict of interest as a risk of study bias.<sup>68</sup>

In summary, **Guideline and GLP studies have significant scientific limitations and decision-makers must utilize non-industry scientific studies in chemical hazard determinations.** All evidence should be evaluated within a systematic review framework that considers risk of bias from financial conflict of interest.

## B. Evaluate and regulate chemicals by classes rather than one chemical at a time.

Decisionmakers can save significant time and resources and avoid damaging and deadly delays by evaluating and regulating chemicals together in groups, instead of one at a time.<sup>69</sup> Chemicals with little or no hazard information or toxicity testing data should be treated as if they are similar to related chemicals that are better characterized. A chemical class approach is necessary if we are to move past the problem of data gaps and data uncertainty that is used as an excuse to delay regulatory restrictions and protective actions.

Further, **a class-based approach will avoid the problem of industry swapping in a closely related chemical that is similarly dangerous to the one it is replacing, called ‘regrettable substitution.’**

For example, replacing the plastic-related chemical Bisphenol A (BPA) with Bisphenol S and Bisphenol F (both of which share a similar toxicity profile to BPA but neither of which were regulated at the time) meant that an unsuspecting public – and in some cases also downstream product manufacturers – continued to be exposed to similarly hazardous compounds.<sup>70,71</sup>

In another example, the toxicity has been well-characterized for only a small number of the roughly 15,000 PFAS chemicals, also called ‘forever chemicals’ because they accumulate in the environment and can last for decades, centuries or millennia.<sup>72</sup> They are used in myriad products to make them heat resistant, grease proof, stain resistant, and waterproof. Of the roughly 600 PFAS compounds that are used in the U.S. in hundreds of products used in homes and workplaces, only a few dozen are even monitored.<sup>73</sup> PFAS contaminates soil, water, products, people and wildlife worldwide.<sup>74</sup> This is especially disturbing given that a number of PFAS are linked with kidney and testicular cancer, thyroid disease, liver damage, birth defects, high cholesterol, pregnancy hypertension, and problems with the immune system.<sup>75</sup> Because PFAS persist and are mobile, they easily circulate through our soil, water, and food, so we can eat, drink, inhale and absorb them in many different ways. PFAS is literally falling down on us in rainwater, at levels that exceed health-risk based benchmarks—and it is very difficult to remediate this contamination.<sup>76</sup>

There is strong scientific basis for regulating PFAS as a class based on their shared physicochemical, environmental and toxicological properties; scientists and others are urging rapid restrictions due to the global health threats these chemicals pose.<sup>77</sup> In response, in February 2023, the EU proposed restrictions on the class of PFAS, which now includes up to 15,000 chemicals.<sup>78</sup> A number of U.S. states have enacted bans on the use of all PFAS in food packaging, textiles, cosmetics, and other products.<sup>79</sup>

Grouping chemicals into classes based on shared structure, such as the above examples of bisphenols and PFAS, is not the only approach. Chemical classes could also be made based on shared toxic effects such as endocrine disruption activity. This approach has been recommended by scientific experts including the U.S. National Academies for the class of chemicals called phthalates based on

their adverse effects on the development of the male reproductive system.<sup>80</sup> Another approach is to group chemicals based on shared chemistry and use, such as organohalogen flame retardants.<sup>81</sup> US states have restricted the class of organohalogen flame retardants in product categories including furniture and children's products, and the U.S. Consumer Product Safety Commission recommended that manufacturers not use these chemicals because they all present health hazards.<sup>82</sup>

In yet another approach, the European Environmental Bureau and others have proposed addressing chemicals as a class based on the physical properties of persistence and mobility in the environment and the propensity to bioaccumulate in organisms.<sup>83</sup> There is a significant precedent for a chemical grouping like this. Chemicals such as polychlorinated biphenyls (PCBs) and chlorofluorocarbons (CFCs) were grouped and regulated based on being both toxic and highly persistent in the environment. The 2001 Stockholm Convention of Persistent Organic Pollutants (POPs) and the European Union REACH regulations both adopted the criteria of “very persistent” as a basis for identifying chemicals of serious concern. In 2021 the state of California also decided to regulate PFAS chemicals in carpets and rugs as a class based on persistence.<sup>84</sup> In a very different approach, the U.S. EPA issued Effluent Guidelines that require industrial facilities to achieve the regulatory standards that are developed based on a particular pollution treatment technology.<sup>85</sup>

As evidenced by the examples of class regulation above, **government agencies already largely have the authorities they need to evaluate and restrict chemicals as classes.** For example, TSCA explicitly authorizes EPA to act on a “category of chemical substances or mixtures.”<sup>86</sup> Use of chemical classes is also consistent with scientific best practices and established approaches by states, countries, and global agreements. Depending on the decision context,

different approaches to identifying and regulating chemical classes are appropriate and scientifically justified.<sup>87</sup>

## C. Include and address additional impacts across chemical life cycles.

The total harm caused by a hazardous chemical is greater than the impacts from just the one chemical itself—very often, hazardous chemicals require other hazardous chemicals in their manufacture, and may break down and release additional hazardous chemicals during their use and in their end of life management. Usually, chemical evaluations focus only on the hazards of a single chemical, but the full range of hazardous chemicals involved in a chemical of concern's life cycle are never considered.

For example, hydrofluoroolefins (HFOs) are being used as replacements for refrigerants with high global warming potential. While HFOs have lower global warming potential, their manufacture requires highly toxic chemicals such as carbon tetrachloride and methylene chloride, both carcinogens. As noted above, methylene chloride is also acutely toxic and exposures can be fatal, especially for workers who are more highly exposed. Thus, HFO manufacture can expose workers and surrounding communities to dangerous and cancer-causing chemicals. Further, carbon tetrachloride is an ozone-depleting substance and its use as a chemical feedstock contributes to ozone-depleting emissions.<sup>88</sup> After release, some HFOs break down into trifluoroacetic acid, a chemical that is a PFAS and chemical of concern, and increasingly accumulating in the environment.<sup>89</sup> Yet, none of these manufacturing or end of life impacts has been included in government evaluations of health and environmental hazards of HFOs.

---

Another example is methylene diphenyl diisocyanate (MDI), a toxic chemical used to make spray polyurethane foam and other products. MDI has well-known health hazards including being a respiratory sensitizer; but what chemical evaluations fail to consider is the impacts of MDI manufacturing, which generates on average more than 47 million pounds of hazardous chemical waste and releases to air and water every year in the U.S.<sup>90</sup> Similarly, evaluations also fail to consider the impacts of incineration and landfilling of MDI-containing products at the end of life.

In all these cases, only considering the hazards of the chemical of concern leaves out a large number of significant health and environmental impacts from other hazardous chemicals used or released in manufacture and at the end of life of the chemical. For evaluations to accurately capture harms related to a chemical, they must consider the impacts of all hazardous chemicals related to the chemical of concern's life cycle, including in manufacture and at end of life.

# RECOMMENDATIONS

Pressure from regulated industries, along with captured regulatory agencies, operating within weak laws and regulations, can make it difficult or impossible to impose commonsense restrictions on chemicals, even when there is robust evidence of harm. The burden of documenting every mechanism through which a chemical causes harm can become an excuse for regulated industries and industry-friendly regulators to delay and ultimately derail regulations. This constitutes a central problem for advocates and health professionals who want to protect people and the planet from toxic chemicals. People of color, frontline communities, and workers - among others - often bear the most severe impacts to their health from these failed approaches. As importantly, flawed and industry-biased chemical hazard and risk evaluations, and weak or ineffective risk management requirements, undermine efforts to transform market economies and innovations towards truly safe chemicals.

To remedy this problem, stakeholders, especially governments, should make better use of existing data and information, regulate chemicals by classes, and consider additional impacts across chemical life cycles to support timely and precautionary action. We have enough data and evidence to act on the many classes of known hazardous chemicals now. We recommend:

- Chemical hazard assessment, not risk assessment, should form the basis for chemical regulation. The outdated “risk assessment” paradigm allows frontline communities, workers, biologically susceptible people, and others to suffer disproportionate exposures, harm, and cumulative impacts from toxic chemicals even when there is robust evidence that the chemical is hazardous. We must shift our chemical man-

agement systems to focus on hazard, not risk. In doing so, we must ensure that updated and more protective U.S. policies do not shift toxic burdens to other countries.

- Chemical hazard evaluations should use a systematic review framework. The framework should have undergone peer review and public input, and consider financial conflicts of interest as a risk of bias. Evaluations should align with scientific best practices, and evaluate and integrate all relevant data and information transparently.
- Identify full chemical hazards over the life cycle and fill data gaps using existing information. Community knowledge, public data, and established methods including science-based adjustment factors, read-across methods (which predict the properties of a chemical by comparing it to similar chemicals), and chemical grouping/classes should all be used to identify chemical hazards and fill data gaps. Hazards of chemicals used or released in the manufacture of a chemical of concern, or released at the end of life of a chemical of concern, should be included in the hazard identification.
- Robust evidence of harm should trigger protective actions to quickly end production and use of hazardous chemicals and chemical classes; data gaps and uncertainty should not be weaponized to further delay environmental health protections. Scientists are concerned that our production and release of hazardous chemicals is beyond what Earth’s systems can handle.
- Decades of experience show that the current regulatory frameworks ignore extensive evidence of harm and primarily protect the interests of the chemical and fossil fuel industries.

- 
- Chemical policies should be accountable for reducing disparities in the most impacted populations. The evidence is clear that toxic chemicals disproportionately harm the health of low-income communities, people of color, workers, frontline communities and others that have had their economic and political power suppressed through systems of oppression including racism.

Chemical regulations should include mandates to ensure that the use, environmental release and population exposures to hazardous chemicals are declining for these populations.

## Conclusion

We have the scientific knowledge and tools to identify hazardous chemicals and chemical classes, and to inform management approaches that ensure the health, safety, and functioning of society while minimizing and ultimately eliminating such chemicals. What we need now is to use the science and tools available to take protective action, so that people and ecosystems across the planet can thrive free from toxic chemicals.

# ENDNOTES

- 1 Toxic Free Future. Research Report: PVC Poison Plastic. April 13, 2023. <https://toxicfreefuture.org/research/pvc-poison-plastic/>
- 2 Landrigan PJ, Fuller R, Acosta NJR, Adeyi O, Arnold R, Basu N (Nil), et al. The Lancet Commission on pollution and health. *Lancet* [Internet]. 2018 Feb;391(10119):462–512. Available from: <http://linkinghub.elsevier.com/retrieve/pii/S0140673617323450>
- Attina TM, Hauser R, Sathyanarayana S, Hunt PA, Bourguignon J, Myers JP, et al. Exposure to endocrine-disrupting chemicals in the USA: a population-based disease burden and cost analysis. *Lancet Diabetes Endocrinol* [Internet]. 2016 Dec;4(12):996–1003. Available from: [http://dx.doi.org/10.1016/S2213-8587\(16\)30275-3](http://dx.doi.org/10.1016/S2213-8587(16)30275-3)
- Trasande L, Zoeller RT, Hass U, Kortenkamp A, Grandjean P, Myers JP, et al. Estimating Burden and Disease Costs of Exposure to Endocrine-Disrupting Chemicals in the European Union. *J Clin Endocrinol Metab*. 2015 Apr;100(4):1245-55. doi: 10.1210/jc.2014-4324. Epub 2015 Mar 5. PMID: 25742516; PMCID: PMC4399291.
- 3 Environmental Justice Health Alliance For Chemical Policy Reform (EJHA), Coming Clean, Campaign For Healthier Solutions. *Life at the Fenceline: Understanding Cumulative Health Hazards in Environmental Justice Communities*. 2018. <https://ej4all.org/life-at-the-fenceline>
- 4 Donley N, Bullard RD, Economos J, Figueroa I, Lee J, Liebman AK, Martinez DN, Shafiei F. Pesticides and environmental injustice in the USA: root causes, current regulatory reinforcement and a path forward. *BMC Public Health*. 2022 Apr 19;22(1):708. <https://pubmed.ncbi.nlm.nih.gov/35436924/>
- Mohai P, Saha R. *Racial Inequality in the Distribution of Hazardous Waste: A National-Level Reassessment*. Social Problems. [Oxford University Press, Society for the Study of Social Problems]; 2007;54:343–70.
- Mohai P, Lantz PM, Morenoff J, House JS, Mero RP. Racial and Socioeconomic Disparities in Residential Proximity to Polluting Industrial Facilities: Evidence From the Americans' Changing Lives Study. *Am J Public Health*. 2009;99:S649–56.
- Cushing L, Faust J, August LM, Cendak R, Wieland W, Alexeeff G. Racial/Ethnic Disparities in Cumulative Environmental Health Impacts in California: Evidence From a Statewide Environmental Justice Screening Tool (CalEnviroScreen 1.1). *Am J Public Health*. 2015;105:2341–8.
- Huang H, Tornero-Velez R, Barzyk TM. Associations between Socio-Demographic Characteristics and Chemical Concentrations Contributing to Cumulative Exposures in the United States. *J Expo Sci Environ Epidemiol*. 2017;27:544–50.
- 5 Burwell-Naney K, Zhang H, Samantapudi A, Jiang C, Dalemarré L, Rice L, et al. Spatial disparity in the distribution of superfund sites in South Carolina: an ecological study. *Environ Health*. 2013;12:96.
- Lee S, Mohai P. *Environmental Justice Implications of Brownfield Redevelopment in the United States*. Society & Natural Resources. Routledge; 2012;25:602–9.
- Environmental Justice and Health Alliance for Chemical Policy Reform (EJHA). *Who's in Danger? Race, Poverty, and Chemical Disasters*. May 2014. <https://comingcleaninc.org/resources/whos-in-danger-report>
- 6 Flores, D., Minovi, D., and Clark, J. *Tanks for Nothing: The Decades-long Failure to Protect the Public from Hazardous Chemical Spills, A National Report and Case Study of Virginia*. The Center for Progressive Reform. December, 2021. Retrieved July 28, 2022 from <https://progressivereform.org/publications/tanks-for-nothing-ast-rpt/>

## ENDNOTES

Coming Clean and Environmental Justice Health Alliance for Chemical Policy Reform. Preventing Disaster: Three chemical incidents within two weeks show urgent need for stronger federal safety requirements. September 2022. <https://comingcleaninc.org/assets/media/images/Reports/Preventing%20Disaster%20final.pdf>

7 Flores D, Kalman C, Mabson M, Minovi D. Preventing “Double Disasters”. Center for Progressive Reform, Earthjustice, Union of Concerned Scientists. July 2021. <https://www.ucs.org/sites/default/files/2021-07/preventing-double-disasters%20FINAL.pdf>

Coming Clean. Unprepared for Disaster: Chemical Hazards in the Wake of Hurricane Ida. September 29, 2021. [https://www.comingcleaninc.org/assets/media/documents/Unprepared\\_for\\_Disaster\\_FINAL.pdf](https://www.comingcleaninc.org/assets/media/documents/Unprepared_for_Disaster_FINAL.pdf)

8 EJHA et al. Life at the Fenceline. 2018.

EJHA. Who’s in Danger? 2014.

Natural Resources Defense Council, Coming Clean, Environmental Justice Health Alliance. Watered Down Justice. 2019. <https://www.nrdc.org/resources/watered-down-justice>

9 Miller P, Karlsson T, Seguinot Medina S, Waghiyi V. (April 2024.) The Arctic’s Plastic Crisis: Toxic Threats to Health, Human Rights, and Indigenous Lands from the Petrochemical Industry. Alaska Community Action on Toxics and International Pollutants Elimination Network. <https://www.akaction.org/publications/the-arctics-plastic-crisis/>

10 Demas KL, Costenbader KH. Disparities in lupus care and outcomes. *Current Opinion in Rheumatology*. 2009;21:102–9.

Odutola J, Ward MM. Ethnic and socioeconomic disparities in health among patients with rheumatic disease. *Curr Opin Rheumatol*. 2005;17:147–52.

11 Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health*. 1992;82:816–20.

Kanjilal S, Gregg EW, Cheng YJ, Zhang P, Nelson DE, Mensah G, et al. Socioeconomic status and trends in disparities in 4 major risk factors for cardiovascular disease among US adults, 1971-2002. *Arch Intern Med*. 2006;166:2348–55.

12 Loucks EB, Rehkopf DH, Thurston RC, Kawachi I. Socioeconomic disparities in metabolic syndrome differ by gender: evidence from NHANES III. *Ann Epidemiol*. 2007;17:19–26.

Tamayo T, Christian H, Rathmann W. Impact of early psychosocial factors (childhood socioeconomic factors and adversities) on future risk of type 2 diabetes, metabolic disturbances and obesity: a systematic review. *BMC Public Health*. 2010;10:525.

13 Beck AF, Huang B, Simmons JM, Moncrief T, Sauers HS, Chen C, et al. Role of financial and social hardships in asthma racial disparities. *Pediatrics*. 2014;133:431–9.

Hughes HK, Matsui EC, Tschudy MM, Pollack CE, Keet CA. Pediatric Asthma Health Disparities: Race, Hardship, Housing, and Asthma in a National Survey. *Acad Pediatr*. 2017;17:127–34.

14 Clegg LX, Reichman ME, Miller BA, Hankey BF, Singh GK, Lin YD, et al. Impact of socioeconomic status on cancer incidence and stage at diagnosis: selected findings from the surveillance, epidemiology, and end results: National Longitudinal Mortality Study. *Cancer Causes Control*. 2009;20:417–35.

## ENDNOTES

Byers TE, Wolf HJ, Bauer KR, Bolick-Aldrich S, Chen VW, Finch JL, et al. The impact of socioeconomic status on survival after cancer in the United States. *Cancer*. 2008;113:582–91.

15 Ncube CN, Enquobahrie DA, Albert SM, Herrick AL, Burke JG. Association of neighborhood context with offspring risk of preterm birth and low birthweight: A systematic review and meta-analysis of population-based studies. *Soc Sci Med*. 2016;153:156–64.

Bryant AS, Worjolah A, Caughey AB, Washington AE. Racial/ethnic disparities in obstetric outcomes and care: prevalence and determinants. *Am J Obstet Gynecol*. 2010;202:335–43.

16 U.S. EPA. Health impacts of fossil-fuel power plants. Last updated January, 2023. <https://www.epa.gov/mats/healthier-americans>

Varshavsky JR, Rayasam SDG, Sass JB, Axelrad DA, Cranor CF, Hattis D, Hauser R, Koman PD, Marquez EC, Morello-Frosch R, Oksas C, Patton S, Robinson JF, Sathyanarayana S, Shepard PM, Woodruff TJ. Current practice and recommendations for advancing how human variability and susceptibility are considered in chemical risk assessment. *Environ Health*. 2023 Jan 12;21(Suppl 1):133. doi: 10.1186/s12940-022-00940-1. <https://pubmed.ncbi.nlm.nih.gov/36635753/>

Adler NE, Rehkopf DH. U.S. Disparities in Health: Descriptions, Causes, and Mechanisms. *Annual Review of Public Health*. 2008;29:235–52.

17 Knobloch L, Salna B, Hogan A, Postle J, Anderson H. Blue babies and nitrate-contaminated well water. *Environ Health Perspect*. 2000 Jul;108(7):675–8. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1638204/>

18 Sheats N, Baptista A. Addressing Environmental Injustice Through the Adoption of Cumulative Impacts Policies: Policy Brief supporting plank #2 of the Louisville Charter. *Coming Clean*. <https://comingcleaninc.org/assets/media/images/Louisville%20Charter%20content/plank%20%20policy%20brief.pdf>

19 Morello-Frosch R, Zuk M, Jerrett M, Shamasunder B, Kyle AD. Racial & Ethnic Disparities: Understanding The Cumulative Impacts Of Inequalities In Environmental Health: Implications For Policy. *Health Affairs*. 2011;30:5879–87.

Donley N, Bullard RD, Economos J, Figueroa I, Lee J, Liebman AK, Martinez DN, Shafiei F. Pesticides and environmental injustice in the USA: root causes, current regulatory reinforcement and a path forward. *BMC Public Health*. 2022 Apr 19;22(1):708. <https://pubmed.ncbi.nlm.nih.gov/35436924/>

20 Trasande L. When enough data are not enough to enact policy: The failure to ban chlorpyrifos. *PLoS Biol*. 2017;15(12):1–6.

Goldberg RF, Vandenberg LN. The science of spin: targeted strategies to manufacture doubt with detrimental effects on environmental and public health. *Environ Heal [Internet]*. 2021 Dec 26 [cited 2021 Apr 5];20(1):33. Available from: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-021-00723-0>

Blumenthal J, Diamond ML, Hoffmann M, Wang Z. Time to Break the “Lock-In” Impediments to Chemicals Management. *Environ Sci Technol*. 2022;56(7):3863–70.

21 Sass J, Rosenberg D. The Delay Game: How the Chemical Industry Ducks Regulation of the Most Toxic Substances. *Natural Resources Defense Council*. October, 2011. <https://www.nrdc.org/sites/default/files/IrisDelayReport.pdf>

# ENDNOTES

- 22 Boyd, W. 2024. Everywhere and Forever All at Once: PFAS and the Failures of Chemicals Regulation: Environmental law helped create a world awash in toxic chemicals; It's time to think about how regulation can operate as a form of green industrial policy for chemicals. Legal Planet. May 29, 2024. <https://legal-planet.org/2024/05/29/pfas-and-the-failures-of-chemicals-regulation/>
- 23 Trager R. Explainer: Toxic Substances Control Act. Chemistry World. June 9, 2016. <https://www.chemistryworld.com/news/explainer-toxic-substances-control-act/1010187.article>
- 24 Wang Z, Walker GW, Muir DCG, Nagatani-Yoshida K. Toward a Global Understanding of Chemical Pollution: A First Comprehensive Analysis of National and Regional Chemical Inventories. Environ Sci Technol. 2020 Jan 22;54(5):2575–84.
- 25 Persson L, Carney Almroth BM, Collins CD, Cornell S, de Wit CA, Diamond ML, et al. Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. Environ Sci Technol [Internet]. 2022 Feb 1;56(3):1510–21. Available from: <https://pubs.acs.org/doi/10.1021/acs.est.1c04158>
- 26 Richardson K et al. Earth beyond six of nine planetary boundaries. Science Advances. September 13, 2023. <https://www.science.org/doi/10.1126/sciadv.adh2458>
- Fenner K, Scheringer M. The Need for Chemical Simplification As a Logical Consequence of Ever-Increasing Chemical Pollution. Environ Sci Technol [Internet]. 2021 Nov 2;55(21):14470–2. Available from: <https://pubs.acs.org/doi/10.1021/acs.est.1c04903>
- 27 Lawrence F. Truth decay: When uncertainty is weaponized. Nature. 2020. <https://doi.org/10.1038/d41586-020-00273-4>.
- 28 U.S. Environmental Protection Agency: Green Chemistry. <https://www.epa.gov/greenchemistry>
- 29 Thorpe B. Transforming the Chemical Industry: Safer Substitutes and Solutions for a Non-Toxic Economy: Policy Paper #3 for the Louisville Charter. Coming Clean. July 2022. <http://bit.ly/42uo9TZ>
- 30 Sheats N, Baptista A.
- 31 National Research Council. Science and Decisions: Advancing Risk Assessment [Internet]. Washington, D.C.: National Academies Press; 2009. Available from: <https://www.nap.edu/catalog/12209/science-and-decisions-advancing-risk-assessment>
- Woodruff TJ, Rayasam SDG, Axelrad DA, Koman PD, Chartres N, Bennett DH, et al. A science-based agenda for health-protective chemical assessments and decisions: overview and consensus statement. Environ Heal [Internet]. 2023 Jan 12;21(S1):132. Available from: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00930-3>
- 32 International Association for Public Participation. Spectrum of Public Participation. [https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum\\_8.5x11\\_Print.pdf](https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf)
- 33 First National People of Color Environmental Leadership Summit. The Principles of Environmental Justice. October 1991. <https://www.ejnet.org/ej/principles.pdf>
- 34 PAN 2023. Pesticides and Climate Change: A Vicious Cycle. Winter 2022-2023. Pesticide Action Network. <https://www.panna.org/wp-content/uploads/2023/02/202301ClimateChangeEngFINAL.pdf>
- 35 Chartres N, Sass JB, Gee D, Bălan SA, Birnbaum L, Cogliano VJ, Cooper C, Fedinick KP, Harrison RM, Kolossa-Gehring M, Mandrioli D, Mitchell MA, Norris SL, Portier CJ, Straif K, Vermeire T. Conducting evalua-

## ENDNOTES

tions of evidence that are transparent, timely and can lead to health-protective actions. *Environ Health*. 2022 Dec 5;21(1):123. <https://pubmed.ncbi.nlm.nih.gov/36471342/>

36 Berheim, E.H., Jenks, J.A., Lundgren, J.G. *et al.* Effects of Neonicotinoid Insecticides on Physiology and Reproductive Characteristics of Captive Female and Fawn White-tailed Deer. *Sci Rep* 9, 4534 (2019). <https://doi.org/10.1038/s41598-019-40994-9>

37 Hoang A, Fagan K, Cannon DL, Rayasam SDG, Harrison R, Shusterman D, et al. Assessment of Methylene Chloride-Related Fatalities in the United States, 1980-2018. *JAMA Intern Med* [Internet]. 2021 Jun 1 [cited 2021 Apr 19];181(6):797. Available from: <https://jamanetwork.com/>

38 U.S. Environmental Protection Agency. Environmental Compliance and History Online (ECHO). <https://echo.epa.gov/>

39 U.S. Environmental Protection Agency. Toxic Release Inventory. <https://www.epa.gov/toxics-release-inventory-tri-program>

40 Pullen Fedinick K, Yiliqi I, Lam Y, Lennett D, Singla V, Rotkin-Ellman M, et al. A Cumulative Framework for Identifying Overburdened Populations under the Toxic Substances Control Act: Formaldehyde Case Study. *Int J Environ Res Public Health* [Internet]. 2021 Jun 3;18(11):6002. Available from: <https://www.mdpi.com/1660-4601/18/11/6002>

41 Coalition to Prevent Chemical Disasters. Chemical Incident Tracker. <https://preventchemicaldisasters.org/>

42 Sheats N, Baptista A.

43 Maffini M V., Geueke B, Groh K, Carney Almroth B, Muncke J. Role of epidemiology in risk assessment: a case study of five ortho-phthalates. *Environ Heal* [Internet]. 2021 Dec 15;20(1):114. Available from: <https://eh-journal.biomedcentral.com/articles/10.1186/s12940-021-00799-8>

44 Nachman KE, Fox MA, Sheehan MC, Burke TA, Rodricks J V, Woodruff TJ. Leveraging epidemiology to improve risk assessment. *Open Epidemiol J*. 2011;4:3–29.

45 Soskolne CL, Kramer S, Ramos-Bonilla JP, Mandrioli D, Sass J, Gochfeld M, Cranor CF, Advani S, Bero LA. Toolkit for detecting misused epidemiological methods. *Environ Health*. 2021 Aug 19;20(1):90. <https://pubmed.ncbi.nlm.nih.gov/34412643/>

Ong EK, Glantz SA. Constructing “sound science” and “good epidemiology”: tobacco, lawyers, and public relations firms. *Am J Public Health* [Internet]. 2001 Nov [cited 2015 Nov 17];91(11):1749–57. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1446868&tool=pmcentrez&rendertype=abstract>

46 European Chemicals Agency. Read-Across Assessment Framework (RAAF). 2017. [https://echa.europa.eu/documents/10162/17221/raaf\\_en.pdf/614e5d61-891d-4154-8a47-87efebd1851a](https://echa.europa.eu/documents/10162/17221/raaf_en.pdf/614e5d61-891d-4154-8a47-87efebd1851a)

47 UCSF Program on Reproductive Health and the Environment. Using the Best Available Science to Assess Hazards and Risks of Industrial Chemicals Will Ensure Better Public Health Decisions. <https://prhe.ucsf.edu/sites/g/files/tksra341/f/wysiwyg/UCSF%20PRHE%20EPA%20Chemical%20Policy%20v1.pdf>

Varshavsky JR, Rayasam SDG, Sass JB, Axelrad DA, Cranor CF, Hattis D, et al. Current practice and recommendations for advancing how human variability and susceptibility are considered in chemical risk assessment.

# ENDNOTES

- Environ Heal [Internet]. 2023 Jan 12;21(S1):133. Available from: <https://doi.org/10.1186/s12940-022-00940-1>
- 48 EJHA et al. Life at the Fenceline. 2018.
- 49 Chartres N, Sass JB, Gee D, Bălan SA, Birnbaum L, Coglianò VJ, Cooper C, Fedinick KP, Harrison RM, Kolossa-Gehring M, Mandrioli D, Mitchell MA, Norris SL, Portier CJ, Straif K, Vermeire T. Conducting evaluations of evidence that are transparent, timely and can lead to health-protective actions. *Environ Health*. 2022 Dec 5;21(1):123. <https://pubmed.ncbi.nlm.nih.gov/36471342/>
- 50 UCSF PRHE. To Ensure Transparent and Unbiased Evaluation of Chemical Harms, EPA Should Use Science-Based Systematic Review Methods. <https://prhe.ucsf.edu/sites/g/files/tkssra341/f/wysiwyg/UCSF%20PRHE%20EPA%20Systematic%20Review%20v1.pdf>
- 51 Sutton P, Chartres N, Rayasam SDG, Daniels N, Lam J, Maghrbi E, Woodruff TJ. Reviews in environmental health: How systematic are they? *Environ Int*. 2021 Jul;152:106473. doi: 10.1016/j.envint.2021.106473. Epub 2021 Mar 30. <https://pubmed.ncbi.nlm.nih.gov/33798823/>
- 52 International Agency for Research on Cancer. IARC monographs on the identification of carcinogenic hazards to humans: preamble. 2019. <https://monographs.iarc.who.int/wp-content/uploads/2019/07/Preamble-2019.pdf>
- Samet JM, Chiu WA, Coglianò V, Jinot J, Kriebel D, Lunn RM, Beland FA, Bero L, Browne P, Fritschi L, Kanno J, Lachenmeier DW, Lan Q, Lasfargues G, Le Curieux F, Peters S, Shubat P, Sone H, White MC, Williamson J, Yakubovskaya M, Siemiatycki J, White PA, Guyton KZ, Schubauer-Berigan MK, Hall AL, Grosse Y, Bouvard V, Benbrahim-Tallaa L, El Ghissassi F, Lauby-Secretan B, Armstrong B, Saracci R, Zavadil J, Straif K, Wild CP. The IARC Monographs: Updated Procedures for Modern and Transparent Evidence Synthesis in Cancer Hazard Identification. *J Natl Cancer Inst*. 2020 Jan 1;112(1):30-37. <https://pubmed.ncbi.nlm.nih.gov/31498409/>
- 53 Woodruff TJ, Sutton P. The Navigation Guide systematic review methodology: a rigorous and transparent method for translating environmental health science into better health outcomes. *Environ Health Perspect*. 2014 Oct;122(10):1007-14. <https://pubmed.ncbi.nlm.nih.gov/24968373/>
- 54 National Toxicology Program. Report on Carcinogens Handbook on Methods for Conducting Cancer Hazard Evaluations. U.S. Department of Health and Human Services. 2025. <https://ntp.niehs.nih.gov/research/assessments/cancer/handbook>
- 55 National Toxicology Program. Handbook for conducting a literature-based health assessment using OHAT approach for systematic review and evidence integration. U.S. Department of Health and Human Services. 2019. [https://ntp.niehs.nih.gov/ntp/ohat/pubs/handbookmarch2019\\_508.pdf](https://ntp.niehs.nih.gov/ntp/ohat/pubs/handbookmarch2019_508.pdf)
- 56 Vandenberg LN, Ågerstrand M, Beronius A, Beausoleil C, Bergman Å, Bero LA, Bornehag CG, Boyer CS, Cooper GS, Cotgreave I, Gee D, Grandjean P, Guyton KZ, Hass U, Heindel JJ, Jobling S, Kidd KA, Kortenkamp A, Macleod MR, Martin OV, Norinder U, Scheringer M, Thayer KA, Toppari J, Whaley P, Woodruff TJ, Rudén C. A proposed framework for the systematic review and integrated assessment (SYRINA) of endocrine disrupting chemicals. *Environ Health*. 2016 Jul 14;15(1):74. 2016. <https://doi.org/10.1186/S12940-016-0156-6>
- 57 Mandrioli D, Schlünssen V, Adam B, Cohen RA, Colosio C, Chen W, Fischer A, Godderis L, Göen T, Ivanov ID, Leppink N, Mandic-Rajcevic S, Masci F, Nemery B, Pega F, Prüss-Üstün A, Sgargi D, Ujita Y, van der Mierden S, Zungu M, Scheepers PTJ. WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of occupational exposure to dusts and/or fibres and of the effect of occupational exposure

# ENDNOTES

to dusts and/or fibres on pneumoconiosis. *Environ Int.* 2018 Oct;119:174-185. <https://pubmed.ncbi.nlm.nih.gov/29958118/>

58 National Academies of Sciences, Engineering, and Medicine. Review of U.S. EPA's ORD staff handbook for developing IRIS assessments: 2020 version. The National Academies Press. 2021. <https://www.nap.edu/catalog/26289/review-of-us-epas-ord-staff-handbook-for-developing-iris-assessments>

National Academies of Science, Engineering, and Medicine. The use of systematic reviews in EPA's Toxic Substances Control Act risk evaluations. 2021. <https://www.nap.edu/catalog/25952/the-use-of-systematic-review-in-epas-toxic-substances-control-act-risk-evaluations>

National Research Council (U.S.) Committee to Review EPA's Draft IRIS Assessment of Formaldehyde. Review of the Environmental Protection Agency's draft IRIS assessment of formaldehyde. 2011. <https://www.ncbi.nlm.nih.gov/books/NBK208227/>

59 Thorpe B.

60 Chartres N, Sass JB, Gee D, Bălan SA, Birnbaum L, Cogliano VJ, Cooper C, Fedinick KP, Harrison RM, Kolossa-Gehring M, Mandrioli D, Mitchell MA, Norris SL, Portier CJ, Straif K, Vermeire T. Conducting evaluations of evidence that are transparent, timely and can lead to health-protective actions. *Environ Health.* 2022 Dec 5;21(1):123. <https://pubmed.ncbi.nlm.nih.gov/36471342/>

61 Smith MT, Guyton KZ, Gibbons CF, Fritz JM, Portier CJ, Rusyn I, et al. Key characteristics of carcinogens as a basis for organizing data on mechanisms of carcinogenesis. Vol. 124, *Environmental Health Perspectives*. Public Health Services, U.S. Dept of Health and Human Services; 2016. p. 713–21.

62 Rosner D, Markowitz G. "Ashamed to Put My Name to It": Monsanto, Industrial Bio-Test Laboratories, and the Use of Fraudulent Science, 1969-1985. *Am J Public Health.* 2023 Mar 16:e1-e6. doi: 10.2105/AJPH.2023.307247. Epub ahead of print. PMID: 36926962.

63 Myers JP, vom Saal FS, Akingbemi BT, Arizono K, Belcher S, Colborn T, et al. Why Public Health Agencies Cannot Depend on Good Laboratory Practices as a Criterion for Selecting Data: The Case of Bisphenol A. *Environ Health Perspect* [Internet]. 2009 Mar [cited 2015 May 4];117(3):309–15. Available from: <http://ehp.niehs.nih.gov/0800173>

64 NTP. CLARITY-BPA. Chemical Effects in Biological Systems (CEBS). Research Triangle Park, NC (USA): National Toxicology Program (NTP). Accessed 2023-03-30. <https://cebs.niehs.nih.gov/cebs/program/CLARITY-BPA>

CLARITY-BPA Research Program. NTP Research Report on the Consortium Linking Academic and Regulatory Insights on Bisphenol A Toxicity (CLARITY-BPA): A Compendium of Published Findings: Research Report 18 [Internet]. Research Triangle Park (NC): National Toxicology Program; 2021 Oct. <https://pubmed.ncbi.nlm.nih.gov/34910417/>

65 Mie A, Rudén C, Grandjean P. Safety of safety evaluation of pesticides: developmental neurotoxicity of chlorpyrifos and chlorpyrifos-methyl. *Environ Health.* 2018.

Sheppard L, McGrew S, Fenske RA. Flawed analysis of an intentional human dosing study and its impact on chlorpyrifos risk assessments. *Environ Int.* 2020.

# ENDNOTES

Buonsante VA, Muilerman H, Santos T, Robinson C, Tweedale AC. Risk assessment's insensitive toxicity testing may cause it to fail. *Environ Res*. 2014.

Sass JB, Needleman HL. Industry testing of toxic pesticides on human subjects concluded “no effect,” despite the evidence. *Environ Health Perspect*. 2004.

Mandrioli D, Kearns CE, Bero LA. Relationship between research outcomes and risk of bias, study sponsorship, and author financial conflicts of interest in reviews of the effects of artificially sweetened beverages on weight outcomes: a systematic review of reviews. *PLoS One*. 2016.

Michaels D. *Doubt is their product: How industry's assault on science threatens your health*. 1st ed. New York: Oxford University Press; 2008.

Michaels D. *The triumph of doubt: Dark money and the science of deception*. 1st ed. New York: Oxford University Press; 2020.

Lerner S. *The department of yes: how pesticide companies corrupted the EPA and poisoned America*. 2021. <https://theintercept.com/2021/06/30/epa-pesticides-exposure-opp/>

66 Chartres N, Sass JB, Gee D, Bălan SA, Birnbaum L, Cogliano VJ, Cooper C, Fedinick KP, Harrison RM, Kolossa-Gehring M, Mandrioli D, Mitchell MA, Norris SL, Portier CJ, Straif K, Vermeire T. Conducting evaluations of evidence that are transparent, timely and can lead to health-protective actions. *Environ Health*. 2022 Dec 5;21(1):123. <https://pubmed.ncbi.nlm.nih.gov/36471342/>

67 Chartres N, Sass JB, Gee D, Bălan SA, Birnbaum L, Cogliano VJ, Cooper C, Fedinick KP, Harrison RM, Kolossa-Gehring M, Mandrioli D, Mitchell MA, Norris SL, Portier CJ, Straif K, Vermeire T. Conducting evaluations of evidence that are transparent, timely and can lead to health-protective actions. *Environ Health*. 2022 Dec 5;21(1):123. <https://pubmed.ncbi.nlm.nih.gov/36471342/>

68 UCSF PRHE. We Need the Best Science Free of Conflicts of Interest so Environmental Health Decision-Making Can Protect Public Health. <https://prhe.ucsf.edu/sites/g/files/tkssra341/f/wysiwyg/UCSF%20PRHE%20EPA%20COI%20v1.pdf>

69 Maffini M V., Rayasam SDG, Axelrad DA, Birnbaum LS, Cooper C, Franjevic S, et al. Advancing the science on chemical classes. *Environ Heal* [Internet]. 2023 Jan 12;21(S1):120. Available from: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00919-y>

70 Rochester JR, Bolden AL. Bisphenol S and F: A Systematic Review and Comparison of the Hormonal Activity of Bisphenol A Substitutes. *Environ Health Perspect* [Internet]. 2015 Mar; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/25775505>

71 Pelch K, Wignall JA, Goldstone AE, Ross PK, Blain RB, Shapiro AJ, Holmgren SD, Hsieh JH, Svoboda D, Auerbach SS, Parham FM, Masten SA, Walker V, Rooney A, Thayer KA. A scoping review of the health and toxicological activity of bisphenol A (BPA) structural analogues and functional alternatives. *Toxicology*. 2019 Aug 1;424:152235. doi: 10.1016/j.tox.2019.06.006.

72 National Institute of Environmental Health Sciences. Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS). <https://www.niehs.nih.gov/health/topics/agents/pfc#:~:text=PFAS%20are%20a%20group%20of,the%20U.S.%20Environmental%20Protection%20Agency>

## ENDNOTES

- 73 U.S. Environmental Protection Agency. Method 533: Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry. Citation for EPA method 533 to measure 25 PFAS in drinking water. <https://www.epa.gov/dwanalyticalmethods/method-533-determination-and-polyfluoroalkyl-substances-drinking-water-isotope>
- 74 Andrews, David Q., Tasha Stoiber, Alexis M. Temkin, and Olga V. Naidenko. "Discussion. Has the Human Population Become a Sentinel for the Adverse Effects of PFAS Contamination on Wildlife Health and Endangered Species?" *Science of The Total Environment* 901 (November 25, 2023): 165939. <https://doi.org/10.1016/j.scitotenv.2023.165939>
- 75 PFAS-Tox Database. <https://pfastoxdatabase.org/>
- U.S. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Perfluoroalkyls. May 2021. <https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf>
- 76 Cousins, Ian T., Jana H. Johansson, Matthew E. Salter, Bo Sha, and Martin Scheringer. "Outside the safe operating space of a new planetary boundary for per-and polyfluoroalkyl substances (PFAS)." *Environmental Science & Technology* 56, no. 16 (2022): 11172-11179.
- 77 Kwiatkowski CF, Andrews DQ, Birnbaum LS, Bruton TA, DeWitt JC, Knappe DRU, Maffini MV, Miller MF, Pelch KE, Reade A, Soehl A, Trier X, Venier M, Wagner CC, Wang Z, Blum A. Scientific Basis for Managing PFAS as a Chemical Class. *Environ Sci Technol Lett*. 2020 Aug 11;7(8):532-543. <https://pubmed.ncbi.nlm.nih.gov/34307722/>
- Cousins, Ian T., Jana H. Johansson, Matthew E. Salter, Bo Sha, and Martin Scheringer. "Outside the safe operating space of a new planetary boundary for per-and polyfluoroalkyl substances (PFAS)." *Environmental Science & Technology* 56, no. 16 (2022): 11172-11179.
- 78 ECHA Annex XV Restriction Report: Proposal for a Restriction. [(accessed on 21 February 2023)]. Available online: <https://echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea>
- 79 Safer States. PFAS Policy Toolkit 2024. <https://www.saferstates.org/wp-content/uploads/Safer-States-2024-PFAS-Policy-Toolkit.pdf>
- 80 National Research Council. 2008. Phthalates and Cumulative Risk Assessment: The Tasks Ahead. Washington, DC: The National Academies Press. <https://doi.org/10.17226/12528>
- 81 National Academies of Sciences Engineering and Medicine. A Class Approach to Hazard Assessment of Organohalogen Flame Retardants [Internet]. A Class Approach to Hazard Assessment of Organohalogen Flame Retardants. Washington, D.C.: National Academies Press; 2019 [cited 2019 Aug 9]. Available from: <https://www.nap.edu/catalog/25412>
- 82 Safer States. Policies for addressing toxic flame retardants. <https://www.saferstates.org/priorities/toxic-flame-retardants/>
- 82 FR 45268. Guidance Document on Hazardous Additive, Non-Polymeric Organohalogen Flame Retardants in Certain Consumer Products. <https://www.federalregister.gov/documents/2017/09/28/2017-20733/guidance-document-on-hazardous-additive-non-polymeric-organohalogen-flame-retardants-in-certain>

# ENDNOTES

- 83 Joint NGO letter to the European Commission Re: Need to update the REACH information requirements. February 27, 2023. <https://www.env-health.org/wp-content/uploads/2023/03/20230227-EEB-letter-to-Timmermans-and-relevant-Commissioners.pdf>
- 84 Bălan SA, Mathrani VC, Guo DF, Algazi AM. Regulating PFAS as a chemical class under the California safer consumer products program. *Environ Health Perspect*. 2021. <https://ehp.niehs.nih.gov/doi/full/10.1289/EHP7431>
- 85 EPA. Learn about Effluent Guidelines. September, 2022. <https://www.epa.gov/eg/learn-about-effluent-guidelines>
- 86 Toxic Substances Control Act (TSCA): Administration. 15 U.S.C. § 2625(c).
- 87 Maffini M V., Rayasam SDG, Axelrad DA, Birnbaum LS, Cooper C, Franjevic S, et al. Advancing the science on chemical classes. *Environ Heal* [Internet]. 2023 Jan 12;21(S1):120. Available from: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00919-y>
- 88 Liang, Q., P.A. Newman, and S. Reimann. “SPARC Report on the Mystery of Carbon Tetrachloride.” Stratosphere-troposphere Processes and their Role in Climate, July 2016. [https://www.wcrp-climate.org/WCRP-publications/2016/SPARC\\_Report7\\_2016.pdf](https://www.wcrp-climate.org/WCRP-publications/2016/SPARC_Report7_2016.pdf)
- 89 Atmosphere (2022). The rising threat of HFOs and TFA to health and environment. <https://atmosphere.cool/hfo-tfa-report/>
- Pickard, Heidi M., Alison S. Criscitiello, Daniel Persaud, Christine Spencer, Derek C. G. Muir, Igor Lehnerr, Martin J. Sharp, Amila O. De Silva, and Cora J. Young. “Ice Core Record of Persistent Short-Chain Fluorinated Alkyl Acids: Evidence of the Impact From Global Environmental Regulations.” *Geophysical Research Letters* 47, no. 10 (2020): e2020GL087535. <https://doi.org/10.1029/2020GL087535>
- Joudan, Shira, Amila O. De Silva, and Cora J. Young. “Insufficient Evidence for the Existence of Natural Trifluoroacetic Acid.” *Environmental Science: Processes & Impacts* 23, no. 11 (November 17, 2021): 1641–49. <https://doi.org/10.1039/D1EM00306B>
- Zheng, Guomao, Stephanie M. Eick, and Amina Salamova. “Elevated Levels of Ultrashort- and Short-Chain Perfluoroalkyl Acids in US Homes and People.” *Environmental Science & Technology* 57, no. 42 (October 24, 2023): 15782–93. <https://doi.org/10.1021/acs.est.2c06715>
- 90 Stamm, R. et al. Chemical and Environmental Justice Impacts in the Life Cycle of Building Insulation: Case Study on Isocyanates in Spray Polyurethane Foam. *Energy Efficiency for All*, 2022. <https://healthybuilding.net/reports/24-chemical-and-environmental-justice-impacts-in-the-life-cycle-of-building-insulation>