The Community Guide to Cumulative Impacts

Using Science and Organizing to Advance Public Health Policy

Appendix: An Introduction to the Science and Terminology of Cumulative Impacts

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Introduction

You do not have to be a scientist with an advanced degree to advocate for cumulative impacts policies in your community! This appendix presents some of the scientific terms and bodies of research that you want to become familiar with. Supportive networks like those in Table 1: Guide Co-Developers with Expertise in Cumulative Impacts Policy in The Community Guide to Cumulative Impacts can help you connect with experts you might need along the way. You can get help from both professional scientists and community experts who bring a wealth of lived and policy experience. You got this!

There is science to support both the **how** and the **why** of cumulative impacts.

How does pollution come into contact with people?

What are some ways of estimating if and how much pollution reaches people?

What are some of the impacts of pollutants on people?

What are some methods of estimating the impacts of multiple pollutants on people and including other stressors and burdens?

What can make the impacts of pollution worse?

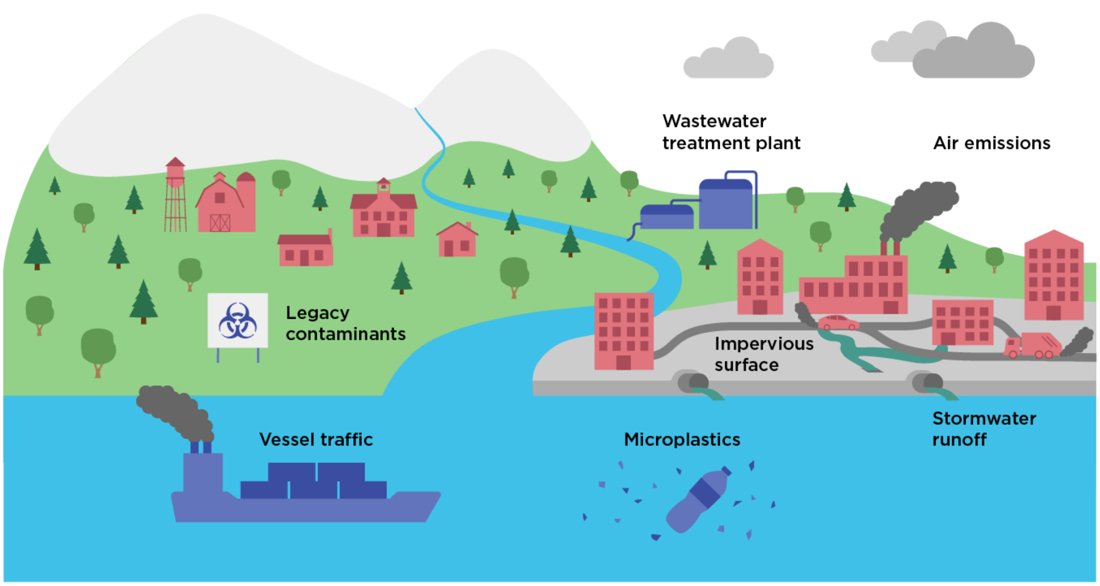
How can our campaign include community measurements and stories in cumulative impact assessments?

Section 1
The Multiple Pathways of Pollution to People

Factories, power plants, roadways, and other contaminated sources release pollution. Once released, pollution can travel through air or water and deposit onto land, water, and built surfaces. When people get near such a surface, they can be exposed to the pollutant that was released or to its breakdown products. A visible example is when wildfire smoke moves to distant parts of the country or even across national borders. Some pollutants tend to be stored longer in certain parts of the environment, like soil, snow, or dissolved in water. Pollution is also present in items used in daily life, like furniture, cosmetics, food, and cleaners.

To address cumulative impacts, environmental policies should incorporate all these possibilities—including pollution sources, everyday items that may contain pollutants, the channels through which pollutants move, and other potential sources of exposure (Figure A-1).

Figure A-1. The pathways of pollution



Harmful chemicals are released from a variety of sources and travel through or accumulate in different parts of our environments. Their chemical and physical properties determine how fast they move and where they might accumulate. Understanding their pathways can help us support and inform policies and policy decisions.

Laws and rules in these states illustrate policy language crafted to protect people from pollution from multiple pathways:

- **Connecticut** (State of Connecticut 2023): "Environmental or public health stressor" means **any source of environmental pollution** that is associated with a potential public health impact.
- **Minnesota** (Minnesota Legislature 2023): "Cumulative impacts" means the impacts of aggregated levels of past and current **air, water, and land pollution** in a defined geographic area to which current residents are exposed.
- **New Jersey** (New Jersey Legislature 2020): "Environmental or public health stressors" means sources of environmental pollution, including, but not limited to, concentrated areas of **air pollution**, mobile sources of **air pollution**, **contaminated sites**, transfer stations or other solid waste facilities, recycling facilities, scrap yards, and point-sources of **water pollution** including, but not limited to, **water pollution** from facilities or combined sewer overflows; or conditions that may cause potential public health impacts.

Exposure, Proximity, and Preventive Action

When people interact with or get close to a polluted or contaminated item, substance, or surface, they are more likely to be exposed to that pollutant or those pollutants. The frequency and amount of time a person is near a pollutant also affects the likelihood of exposure.

However, communities need the protective and preventive action of cumulative impact assessments and policies now rather than after harm appears. The English epidemiologist Austin Bradford Hill, in a classic 1965 paper (Hill 1965) on the theory of how to determine the causes of disease, strongly described the need for preventative action.

Cumulative impacts and EJ tools use "proximity"—being close to a pollution source—to reflect chemical exposure and the other negative impacts of living near contaminated sites or polluting facilities. Indices in cumulative impacts and EJ tools reflect when people are close to pollution. The indices include proximity to:

- Traffic or traffic density;
- An impaired water body;
- Wastewater discharge;
- Superfund or hazardous facility; and
- Facilities releasing toxic pollution.

Section 2
Effects of Cumulative Exposures to Pollution

Exposure to a single chemical can be harmful, yet no one is exposed to only single chemicals. Multiple harmful chemicals in the body can interact with each other in several ways:

- **Additive**: The effect of the combination of chemicals is what you would expect if you added up the impacts.
- **Synergistic**: The effect of the combination of chemicals is more than additive.
- **Antagonist**: The combined effects are less than you would expect if you add them up (less than additive).
- **Potentiation**: Some chemicals may be toxic only if the exposure includes another chemical.

One common method to assess possible interactions is to add up the doses. "Dose addition" requires that the chemicals interact in the exact same way and cause the exact same type of impact.

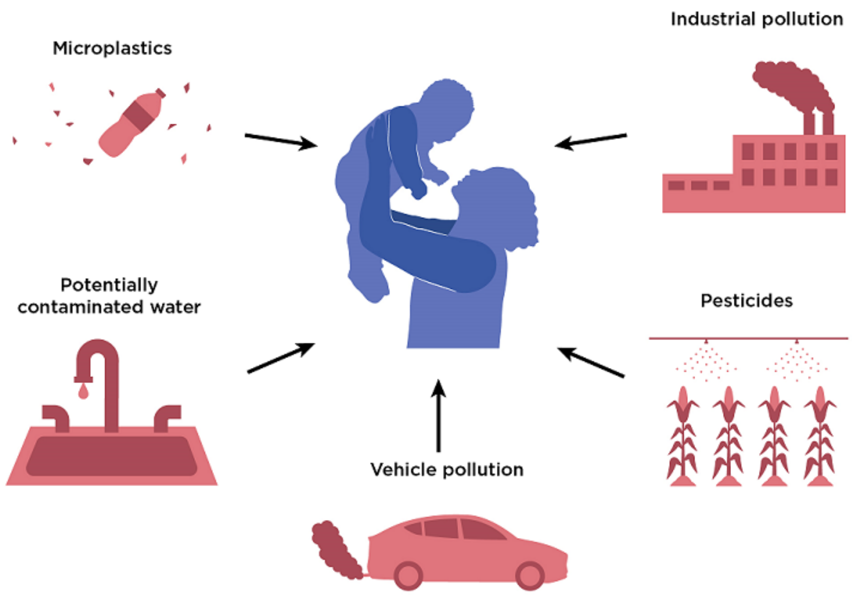
Another way to assess interactions is to add up the responses. "Response addition" sums all chemicals with the same type of response. Adding up responses is less restrictive and more protective than adding up doses.

"The dose makes the poison" is a major plank of the risk-based platform of EPA decisionmaking. Yet this paradigm is increasingly obsolete (Grandjean 2016) with the growing knowledge around increasingly complex body systems, their interactions inside the body, and human interactions in their environments and communities.

Pollutant Accumulation

Pollutants enter our bodies, which metabolize them and then eliminate them by breathing, sweating, or other processes. However, our bodies hold onto some pollutants for long time periods, and sometimes pollutants build up over time ("bioaccumulate"). Also, we may eat animals or plants that have accumulated pollution through the food chain ("biomagnification"). The pollutants that are in people's bodies are sometimes referred to as "pollutant burdens." It takes a great deal of time and intervention to eliminate these burdens from people and the environment (Figure A-2).

Figure A-2. Exposures to and Accumulation of Multiple Harmful Chemicals



Exposure to harmful chemicals and their accumulation in the body follow multiple pathways—from factories, polluted water, aerosols, and much more.

Here are some words to look for to make sure that policies, rules, and definitions are protective of pollutant accumulation over time: "historic burden," "bioaccumulative," "biomagnification," "past exposures," "over time," "existing," "pollutant burden." You can specifically call out the accumulating chemicals in this list (Toxic Free Futures 2023) from Toxic-Free Future, a national organization engaging in environmental health research and advocacy.

Some policies and indicators include pollutant burdens that already exist in a community. For example:

- Cal Enviroscreen specifies the risk to children of lead in housing (California Office of Environmental Health Hazard Assessment 2020).
- The CDC Environmental Justice Index uses the potential for lead exposure and burden in children using housing built before 1980 ("Environmental Justice Index (EJI) Indicators" 2023).
- The New Jersey cumulative impacts law (New Jersey Legislature 2020) specifically refers to the inclusion of blood lead in considering permit limits and issuance.
- The US Toxics Substance Control Act—TSCA section 6(h), 15 U.S.C. 2605(h) (United States Code 2016)—is not a cumulative impacts law, but it contains some requirements to regulate chemicals as classes. It requires the EPA to take expedited action on

chemicals that are more likely to be stored in the body for longer periods of time or "persist, bioaccumulate, and are toxic" (PBT).

- Minnesota's cumulative impacts law (Minnesota Legislature 2023) defines "environmental justice area" using some reference to historic exposures, including "the history of the area's and its residents' cumulative exposure to pollutants."

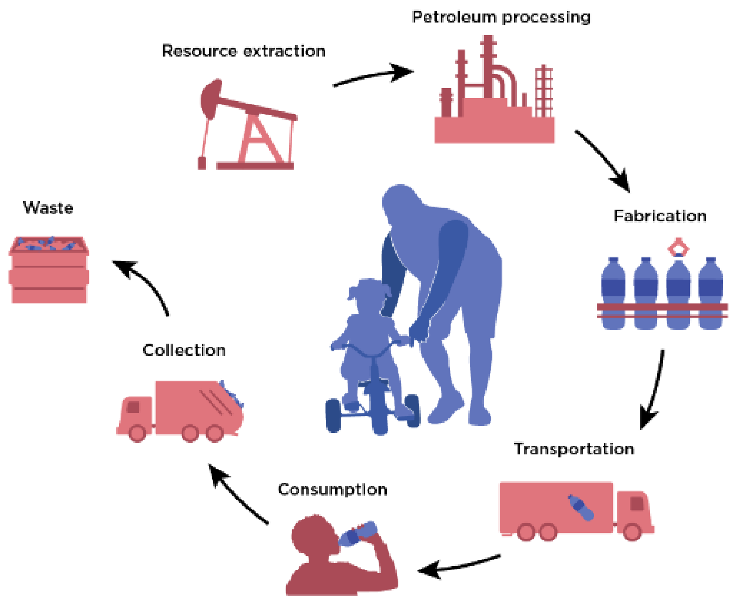
The Harm to People of Persistent Multiple Impacts to Land

Adverse impacts on land over time harm people's health and all aspects related to their connections with the land. Clearcutting forests or removing vegetation is followed by mining, which in turn is followed by polluting industries. These practices rob land of nutrients and biological diversity, and that affects nearby human populations who lose the ability to farm, access wild foods, and benefit from tree canopy.

The Lifecycle of Products Can Repeatedly Harm People

People who are exposed to pollutants many times or continuously over time, even at low levels, have less ability to repair or recover and are more likely to suffer permanent harm. Yet the lifecycles of many products can affect communities multiple times: when the products are manufactured, transported, used, and thrown away (Figure A-3).

Figure A-3. Multiple Impacts on a Community



The lifecycle of a plastic toy may begin with extracting and processing fossil fuel, followed by energy production and manufacturing. All those steps can release pollutants to a community. Then a store sells the toy that contains and releases toxic chemicals, also exposing the child's family and community. Eventually, the toy ends its lifecycle in a dump yard or incinerated, again releasing pollutants. Each step in the process affects the people who live in these communities.

Section 3
Hazard and Risk: The Precautionary Principle

The Coming Clean Louisville Charter (Coming Clean 2021), Plank 6, states, “Act with foresight to protect health.” This is the essence of the precautionary principle. A factsheet from the University of Michigan Environmental Health Science Center of Excellence summarizes the precautionary principle (University of Michigan, School of Public Health 2012) as “better safe than sorry.”

The Precautionary Principle suggests that even with uncertainty about the possibility of harm, actions should be taken to protect health whenever credible evidence of harm exists. An example of putting the principle in practice is a cumulative impacts mapping tool that uses proximity rather than requiring that exposure be proven to a high level of certainty. In the words of Atenas Mena, a nursing leader in Kansas City, Missouri, “We want to be preventive and not reactive.”

A key distinction is between hazards and risks:

- **Hazard**: A potential for harm or adverse health effects on people. Hazards to people could be visualized as a boulder teetering on a cliff.
- **Risk**: The likelihood and magnitude (degree) that a person might be harmed or experience an adverse health effect if exposed to a hazard. So, continuing the analogy, risk relates to the likelihood the boulder will fall on an actual person and the type and extent of damage that would cause.

It is always better to eliminate the hazard (Chemsec 2003) **than to reduce the risk**. This is why scientists, public health experts, sociologists, and EJ professionals advocate for hazard-based approaches. They strongly challenge the traditional risk assessment model because it:

- Is not precautionary;
- Is not health protective;
- Does not reflect the real life of anyone;
- Is extremely expensive to conduct per each chemical; and
- Takes many years to review each individual chemical.

Determining risk requires more data, evidence, and proof than does determining a hazard. Moreover, the data are never fully comprehensive, which means they underestimate risk.

Yet risk assessment is the traditional way that the EPA and other agencies decide whether chemicals are too hazardous to be allowed to be produced, and the extent to which it will allow their release into communities. Risk assessment looks at single chemicals and how they might be released, reach people, enter people's bodies, and cause harm. The results may be how likely it is that harm may occur, or the analysis may compare a level of the chemical with a level considered "safe" or "acceptable." Under this regulatory scheme, bans of even the most harmful chemicals are extremely rare.

Risk assessment is too narrow and restricted to protect human health or the environment. Moreover, traditional, single-chemical risk assessments are expensive, time consuming, and require a high burden of proof for harm. Because of this delay and its reductionist approach, risk assessments are not protective.

Risk assessments:

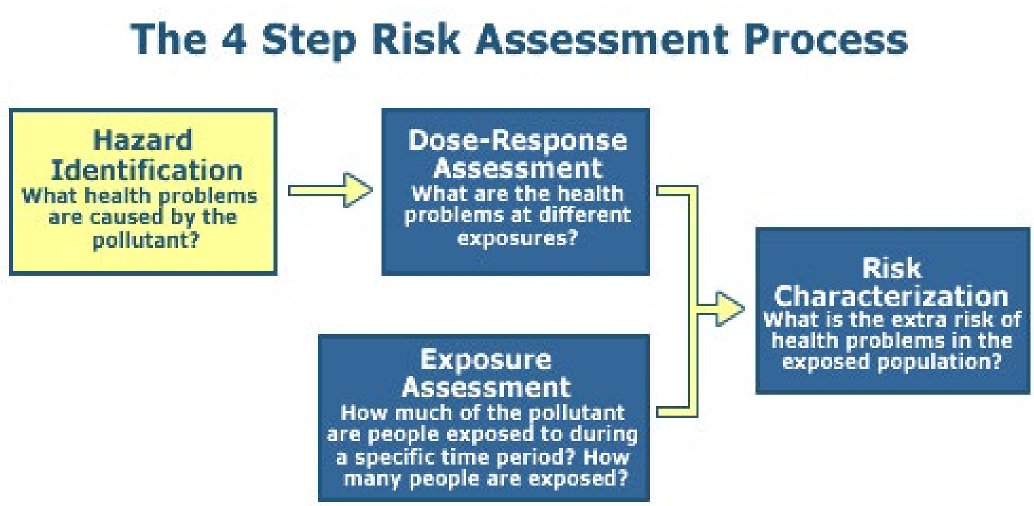
- Do not account for multiple stressors such as social adversity, noise, odors, existing chemical burden, exposure to racism and other biases, and lack of healthy food or adequate health care;
- Do not reflect exposures to multiple chemicals and how their interactions can have a greater impact than separately;
- Tend to be developed based on population averages and are not representative of overburdened communities; and
- Were long tailored to protect healthy, white males and have not evolved adequately.

Section 4
Cumulative Risk and Cumulative Impacts

To reiterate, it is always better to eliminate the hazard than to reduce the risk. However, some proposals would expand the traditional risk assessment process to include more chemicals and "non-chemical stressors." Non-chemical stressors are such things as lacking access to healthy food, lacking adequate health care, or exposure to anything that might cause harm but is not a chemical (e.g., radiation exposure from radon in a home or exposure to harmful biological organisms).

This expansion, called "**cumulative risk assessment**," could follow the steps in Figure A-4. The EPA AirToxScreen (USEPA 2020) is an example of a simple cumulative risk assessment for air pollutants."

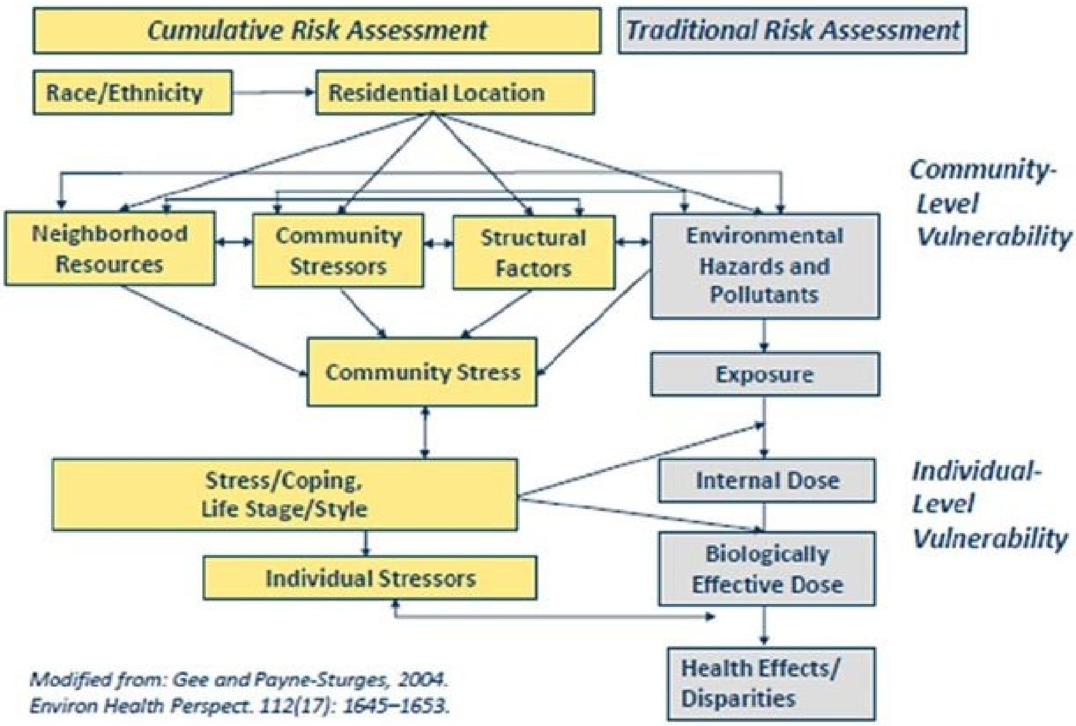
Figure A-4. The Process Diagram of Traditional Risk Assessment



The EPA Risk Assessment process begins with identifying a hazard and ends with characterizing the risk.

SOURCE: FROM THE NATIONAL RESEARCH COUNCIL 1983, "RISK ASSESSMENT IN THE FEDERAL GOVERNMENT. MANAGING THE PROCESS." https://www.epa.gov/risk/conducting-human-health-risk-assessment.

Figure A-5. Comparing Cumulative Risk Assessment and Traditional Risk Assessment



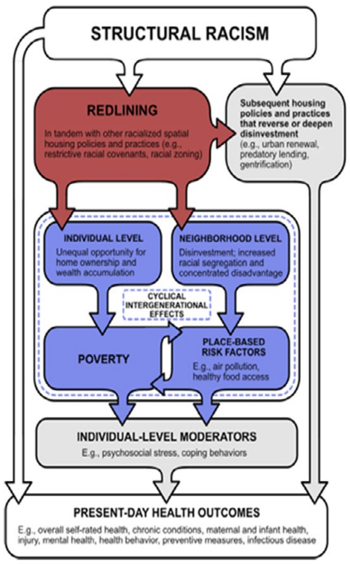
An illustration reflecting the social and health stressors and burdens that are integrated into a cumulative risk assessment in comparison to a single chemical traditional risk assessment.

Discussed in a presentation: Methods and Data for Cumulative Assessment in Disproportionately Impacted Communities, Geller, AM 2021 Original figure - (Gee and Payne-Sturges 2004), modified figure - (Geller 2021)

This is where cumulative impact assessments come in. More recent diagrams of chemical risks incorporate historic injustices that affect present-day health disparities (Figure A-6). These diagrams represent a more complete picture around health disparities, better suiting them to analyses that inform chemical regulation.

Policymakers and regulators, when shown these types of diagram, sometimes belittle chemical risks (“See, chemical risks are only a small part of the picture”). However, the regulation of chemical risk must take the whole story into account because the various types of adversity can exacerbate harm from chemical exposures. This is why communities push for cumulative impacts policies, which can provide a holistic, protective approach based on the presence of multiple hazards and stressors related to environmental pollutants, social adversity, and health conditions.

Figure A-6. Including Structural and Systemic Factors that Add to Cumulative Impacts



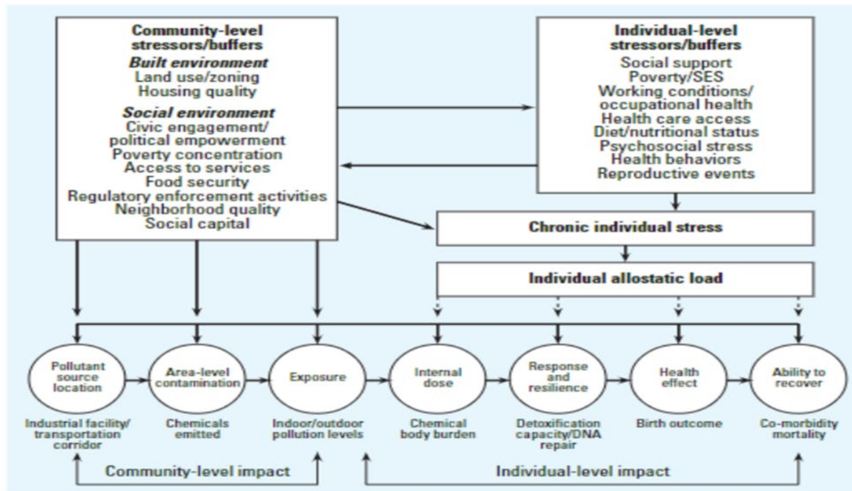


Figure 1. The interplay of community and individual stressors/buffers that shape exposures and susceptibilit to environmental hazards. Thick arrows indicate relationships that have been studied in the epidemiologi and sociology literature; dashed arrows indicate relationships that have not been extensively explored.

Diagrams that more accurately reflect cumulative impacts include the interactions between harmful pollution and health outcomes such as structural and systemic barriers to health, like exposure to racism. (Swope, Hernández, and Cushing 2022) and (Morello-Frosch and Shenassa 2006)

Section 5
Factors That Exacerbate the Impacts of Pollution Exposures

Age and existing health conditions can exacerbate pollutant impacts. Conditions inside the body can affect sensitivity to pollutants, and this can vary in people. Think about the differing reactions to a wasp sting: some people are in pain, while others get a large welt or struggle to breathe. These "intrinsic factors" (Adams and Denton 2010) affect sensitivity; assessments that inform health-based standards and environmental protections need to take them into account. Age and preexisting health conditions, like asthma, can make pollution exposures worse.

Social conditions can make pollutant impacts worse. Environmental pollution on its own relates to many social, health, and ecological impacts (Los Jardines Institute 2022). Moreover, the impacts connect to one another. There is epidemiological evidence that living with adversity—racism, poverty, material hardship—makes exposure to chemicals more harmful. The language that the EPA uses to describe cumulative impacts refers to these adversities as "non-chemical stressors"—basically anything harmful that is not a chemical. The science that includes all of these things together advances and supports cumulative impact assessments.

However, testing every combination of pollutant and social adversity is impossible. Even if it were possible, it would take a very long time. Our communities cannot wait for pollution reduction. In the meantime, it is important to include cumulative impact assessments that determine the potential for all these types of possible harm. Indicators of the potential for harm can come in such forms as measures of poverty in a neighborhood, distance from health care, immigration status, barriers to outside activities, and access to healthy foods. Existing data can capture all these indicators, while community stories of lived experience can inform them directly.

Section 6
Harmful Chemicals in Regulations

Most US environmental protections apply to one chemical at a time or one type of pollution source at a time. They do not take into account other pollutants or sources, other hazards and stressors within a community, and social determinants of health (USHHS 2020) that may make a community more susceptible to environmental harm. Therefore, they drastically underestimate cumulative impacts. One step toward addressing cumulative impacts would be to regulate chemicals as a class (Ellickson 2023).

Some chemical compounds have the same atoms but arranged differently, so they can have different properties. Graphite (pencil lead) and diamonds are a good example: both are forms of graphite. (Play the game 'Pop Organic' (Science Game Center 2018) to learn more). Structures are one factor that inform chemical and physical traits such as whether the compound can dissolve in water or persist in the air at room temperature. Some chemicals can be grouped together because similar environmental processes (USEPA 2023b) form them, such as when fuels are burned or when chlorinated tap water is heated and sprayed in a shower. When we ingest, inhale, or absorb chemicals through our skin, some of those chemicals travel through the body similarly or result in similar adverse health outcomes, such as respiratory irritation or certain cancers. Any of such shared characteristics can be used effectively to group chemicals into classes, such as metals or halogens.

Regulating chemical classes (Maffini et al. 2023) instead of single chemicals avoids regrettable substitutions when manufacturers switch (Toxics Free Futures 2019) from a newly regulated toxic product to one that is also toxic but is less well-studied and less restricted. Grouping chemicals with similar properties, like similar health effects (USEPA 2023a), can help prevent these harmful scenarios and protect people and the environment.

Because chemicals are not regulated as a class helps explain why communities that engage in class-action lawsuits are often unsuccessful. Furthermore, some class-action lawsuits are ineffective because they would need to link one harmful chemical from a specific source to a person with a health effect, and no one is exposed that simply. As Jeannie Economos of the Farmworker Association of Florida said, "*Class action lawsuits didn't work [for us] because of cumulative impacts and . . . no clear outcome from one pesticide to one health outcome.*"

Section 7
Lived Experience and Stories Are Data

Historically, the scientific methods used to inform environmental policies and regulations have predominantly relied on quantitative or numerical measurements and models. However, we also need community context and validation to help ensure that we capture all the information necessary for developing effective, reality-based cumulative impact assessments. Thus, in addition to quantitative (number-based) data, community-based science also includes qualitative data. For example, storytelling, self-reports, and photovoice can inform meaningful reduction of pollution in overburdened and under-invested communities. We can borrow from the social sciences to support the collection and synthesis of qualitative data.

Both qualitative and quantitative community-based data can serve as on-the-ground validation of processes and results, and they can stand on their own to provide vital context for assessments. The Mixed Methods Program (University of Michigan 2023) at the University of Michigan studies how to integrate quantitative and qualitative approaches so that lived experiences and local and traditional ecological knowledge are combined with quantitative measurements and modeling to tell the whole story. This is good science. We need all ways of knowing to assess cumulative impacts of environmental harm to ensure all assessments, interventions, and evaluations are rooted in the real world lived experiences of communities.

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Coming Clean is a nonprofit collaborative of environmental health and justice organizations and experts, working to transform the chemical industry so it is no longer a source of harm.

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The Union of Concerned Scientists puts rigorous, independent science into action, developing solutions and advocating for a healthy, safe, and just future.

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