Cancer & Environment Network of Southwestern Pennsylvania

A Year in Review:
Reflections on the 2024 Peer-Reviewed Research on Cancer and Environment

Another year, another robust collection of literature documenting both new and known cancer risks due to environmental exposures of concern.

The Cancer and Environment Network of Southwestern Pennsylvania's (CENSWPA) "Year in Review" highlights findings from scientific studies published in 2024 that add to the evidence regarding cancer risks associated with exposures in our environment to support risk reduction/cancer prevention strategies. The scientific studies were queried as part of the development of CENSWPA's monthly Digest. Research articles were collected using searches of PubMed, as well as reviews of the table of contents of academic journals that routinely publish on the topic. CENSWPA's review captures seminal articles so that Network participants can stay up to date with relevant research on risks from chemical and radiological toxicants in our environment and workplaces.

CENSWPA action teams reflected on the 2024 collection of articles and identified the following noteworthy themes to highlight in this research brief:

1. The rise in **young adult cancers** raises significant concern about environmental exposures.
2. Research on exposure to **microplastics** is going beyond detecting their presence in the body and now demonstrating concerning cancer risks.
3. A growing number of cancer types are connected with exposure to **PFAS** (per- and polyfluoroalkyl substances).
4. **Cancer severity and survival** are impacted by exposures in our environment.

Each of these themes are reviewed below. Supplemental research and studies that provide supportive evidence and/or additional context for the 2024 research themes are included. In addition, risk reduction strategies are suggested for each of the themes.

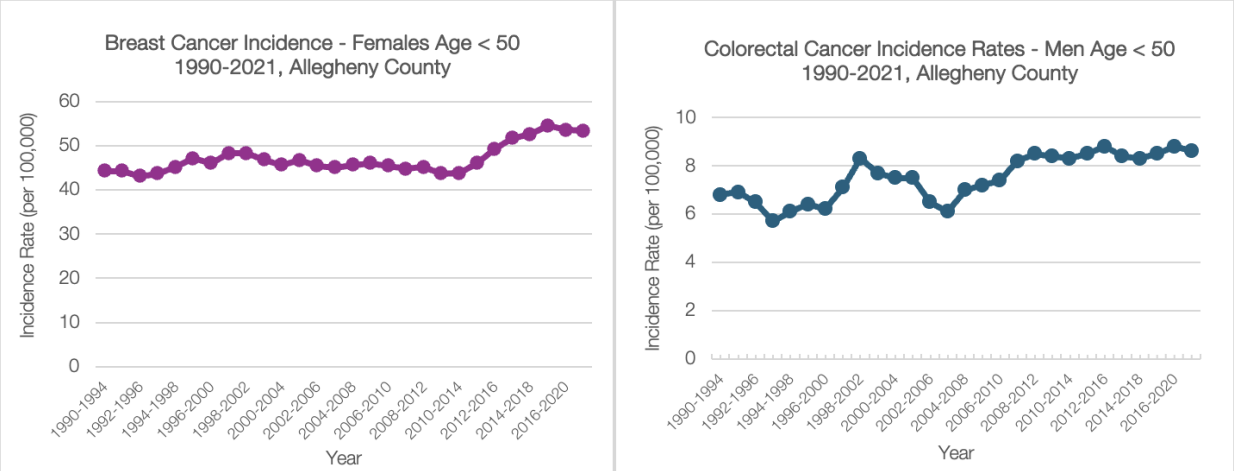
For questions about technical terms used to describe the study results, please see CENSWPA's glossary of terms.

1. The rise in young adult cancers raises significant concern about environmental exposures.

Cancer is widely known as a disease of old age – incidence rates for cancer increase with age with the highest rates occurring among the elderly (NCI, 2021). Yet research is showing a rise in cancer cases among younger adults under the ages of 40 and 50. These "early onset" or "young adult" cancers (as cancer researchers call them) have been the focus of national news in 2024 (Hetter 2024; Stahl 2024). Such trends are concerning; not only because current known risk factors may not fully explain the rising risks but also due to the aggressive nature of these cancers. For example, advanced maternal age is a known reproductive factor that may increase risk for developing breast cancer (Londero et al. 2024). However, this known risk factor does not explain why women in their 20s are increasingly being

diagnosed with the disease. Also concerning is that early onset cancers tend to be more aggressive with lower rates of survival within the first 5 years of diagnosis, especially for cancers such as breast and colon cancers (Siegel et al. 2024).

What is the research telling us? Researchers noted that in the U.S., "progress is lagging in cancer prevention" for younger adults as incidence rates of breast, cervical, colorectal, kidney, melanoma, oropharynx, pancreas, prostate and uterine have increased (Siegel et al. 2024). Colorectal cancer is now the leading cause of death from cancer in younger men and the second-leading cause among younger women (behind breast cancer) (Siegel et al. 2024). CENSWPA reviewed trends of cancer incidence rates that are available through the Pennsylvania Department of Health's Enterprise Data Dissemination Informatics Exchange System (EDDIE). Data shows that incidence cancers are also rising among those under 50 years of age in our region. For example, in Allegheny County, there is a clear increase in recent years in breast and colon cancers (see figures below).



Source: Pennsylvania Department of Health, Enterprise Data Dissemination Informatics Exchange. Data queried January 20, 2025.

Recent studies suggest that risk factors such as unhealthy diet, obesity, and reproductive patterns may be associated with the increasing trends in young adult cancers. However, most of these studies do not include environmental risk factors. Evidence from previous studies suggests that early-life exposure to endocrine-disrupting chemicals (Cohn et al., 2007) and air pollution (Ou et al., 2020) may increase the risk of breast cancer in young adults. Additionally, long-term exposure to hazardous environmental pollutants—such as chemicals, particulate matter, and radioactive gases like radon—can vary based on where individuals live, work, and spend time. Both national and local environmental policies, along with neighborhood environments, influence these exposures. For instance, the absence of radon mitigation policies at the city or county level may heighten radon exposure risks, particularly in poorly ventilated housing and this may be related to earlier onset lung cancers. Although lifestyle and behavioral changes are important, they are not enough on their own to reduce cancer risks. Cancer arises from multiple contributing factors, making it essential for research and prevention strategies to address a combination of causes rather than focusing on a single factor.

What can we do about the rising trends in young adult cancers? CENSWPA encourages health practitioners and the research community to NOT discount environmental risk factors when examining the reasons behind increasing rates of cancer incidence among young adults, and to incorporate these

risks in future research agendas. We do not need to wait for more evidence to act on the knowledge at hand to reduce risk of cancers in younger adults. CENSWPA's review of the science (Jacobs et al. 2021) clearly demonstrates that exposure to environmental risk factors including exposure to air pollution, water pollutants, toxicants in consumer products and pesticides, increases the risks of cancer. Mitigating such carcinogenic exposures through increased education and outreach efforts as well as policy changes will support cancer risk reduction across the entire life span.

2. Research on exposure to microplastics is going beyond detecting their presence in the body and now demonstrating concerning cancer risk.

It was only a few years ago that scientists first detected microplastics in humans (Schwabl et al. 2019). Since then, scientists have detected microplastics in human lungs, heart, blood, breast milk, brain, placenta – basically in every human tissue/fluid examined (Zuri et al. 2023a). Microplastics have also been found in ambient air, drinking water, and food/beverages (Zuri et al. 2023b).

What are microplastics? The production and use of plastics have resulted in extensive pollution of our environment with plastic debris. Among this plastic debris are unintentional microplastics,[1] which are generated during the use of a plastic-containing product or after a plastic product (for example, your plastic beverage bottle, plastic grocery bag or plastic detergent bottle) is disposed of. Plastics undergo physical, biological, and chemical transformations which alter the structural integrity of the plastic and cause it to fragment. For example, microplastics can be formed through fragmentation by physical abrasion, such as through continuous cutting on plastic culinary cutting boards, through the abrasion of synthetic textiles during laundering, through the physical forces of waves, sand, and wind on a beach, or by exposure to the sun's UV radiation. There is no universally accepted definition of microplastics, but are generally defined as plastic particles <5mm (OECD 2021). As plastic materials age and fragment even further, they become nanoplastics (particles with at least one dimension that is 1 -100 nm in size). Sadly, plastics in our environment (including our landfills) never fully decompose, they just get smaller and smaller in size.

It is important to note that microplastics are formed from their parent polymeric/plastic material and there are dozens of widely used plastics with thousands of uses. Studies focus not only on the impacts of microplastics, but also the type of polymers/plastics that are showing up as potentially problematic. Common plastics and familiar uses include for example:

- **polyethylene** – the most common plastic in the world. It is classified into subtypes including:
    - **low-density polyethylene** – used for plastic/cling wrap, sandwich bags, bubble wrap, beverage cups, grocery bags
    - **high-density polyethylene** – used for milk cartons, detergent bottles, cereal box liners, toys
- **polystyrene** (also known as Styrofoam) – used for packing peanuts, clam-shell food containers, coolers, beverage cups (e.g., solo® cups)
- **polypropylene** – used for straws, bottle caps, prescription bottles, hot food containers, packaging tape, disposable diapers

[1] There is also a category of microplastics called, "intentionally added". Intentionally added microplastics, such as microbeads in toothpaste or facial scrubs that have been banned by the FDA as of 2019.

- polypropylene terephthalate – used for beverage bottles (e.g., water bottles), food bottles/jars (e.g., salad dressing, peanut butter, honey, etc.) and polyester clothing
- polyvinyl chloride – used in building materials (e.g., plumbing pipe fixtures, siding), IV medical bags, shower curtains, toys, credit cards

What is the research telling us? Although scientists have clearly documented ubiquitous exposure to both micro- and nanoplastics, what we do not understand yet is the harm they cause, if any. Some of the research published in 2024 has found an association between microplastics and cancer. These studies, based on human exposure data from cancer patients and on research using cellular and animal models, provide early warnings of potential harm.

Several studies in 2024 found microplastics in the tumors of patients diagnosed with breast, cervical, ovarian and prostate cancers. Such direct exposure in the tumor environment raises concern that these materials may be involved in various mechanisms that can induce or promote cancer. For example, Xu and colleagues examined cervical tumors and found significant levels of microplastics composed of polypropylene and polyethylene materials (Xu et al. 2024). A similar study examining prostate tumors found an abundance of polystyrene, polyethylene, and polyvinyl chloride microplastics. These researchers also made a positive correlation regarding the presence of polystyrene in the tumor samples and the frequency of take-out food consumption by the patients (Deng et al. 2024). Tian and colleagues observed a significant accumulation of polystyrene microplastics in the tumors of breast cancer patients and identified a range of cellular impacts associated with microplastics bound to specific cells that are related to known carcinogenic mechanisms (Tian et al. 2024). Chen and colleagues went a step further in their research. They not only documented that polystyrene nanoplastics were present in ovarian tumors, but also discovered that cellular changes associated with these nanoplastics were responsible for accelerating the growth/promotion of the tumor (Chen et al. 2024).

Additional studies explored how micro- and nanoplastics might contribute to cancer. Schnee and colleagues found that both micro- and nano-sized polystyrene particles were absorbed by healthy and cancerous breast cells, with cancer cells absorbing more, especially the smaller nanoparticles. The study also suggested these particles may influence processes linked to cancer progression (Schnee et al. 2024). Ding and colleagues conducted animal studies related to stomach cancer and found that nano-sized polystyrene was particularly harmful, causing oxidative stress and DNA damage — mechanisms associated with the development of cancer. These findings highlight the need for further research on potential risks, including stomach and gastric cancers (Ding et al. 2024).

The collection of studies to date demonstrate that microplastics can infiltrate cells, disrupt biological processes, and potentially foster carcinogenic environments. Research will continue in the coming years to improve our understanding of possible impacts. But until then, these early warning signs suggest a need for caution and to reduce the public's constant exposure to microplastics.

What can we do to reduce potential cancer risks associated with microplastics? Ideally, the task of reducing exposure to microplastics should not fall to the public to figure out given that we are surrounded by plastic products. The United Nations is currently in the process of developing a Global Plastics Treaty to address the pervasive plastics pollution problem, which includes addressing

microplastics. Yet given the current political climate, it is unlikely in the near-term that the U.S. will agree to the legally binding provisions in the treaty. However, policy actions can be pursued at the state-level in Pennsylvania as well as by local governments that reduce demand for plastic products. For example, Pennsylvania can join the numerous states that have already instituted bans on single use plastic bags, straws, and utensils as well as Styrofoam food/beverage containers. Policy efforts that reduce the demand for plastic products are important signals to decrease production. Policy-level strategies are particularly critical for the southwest Pennsylvania region given that the Shell Pennsylvania Petrochemicals Complex in Beaver County produces over a million tons of plastic pellets annually that are used in the global production of a variety of products that are contributing to the plastics pollution/microplastics crisis we are now facing. Because plastic is produced with fossil fuels, supporting policies that will shrink our economy's carbon footprint and its reliance on fossil fuel extraction will also significantly contribute to the reduction in plastic demand and production. For example, limiting the federal and state tax dollars that subsidize plastic production and transitioning to renewable energy sources would slow further petrochemical buildout in southwest Pennsylvania.

Yet as we wait for systemic change to halt plastic production through policy, as individuals, we can try to use fewer plastic products to reduce our exposure to microplastics. It is important to note that there is only so much that we, as individuals, can control. However, "less is better," and there are risk reduction strategies available to limit exposure to microplastics. Recommendations include:

- Eliminating single use plastics as much as possible. Use canvas/cotton bags to shop rather than purchasing reusable plastic bags.
- Replace your plastic cutting board with a wood cutting board.
- If you need a new piece of clothing, check the tag for what it is made of; avoid clothing made of acrylic, polyester nylon, rayon, and other polymers and prioritize purchasing textiles made of cotton, wool, linen and other natural fibers.
- Cut back on foods that come in plastic packaging to the extent possible. Cooking at home rather than getting take-out can help. Buying in bulk can help as well.
- Use shorter dish-washer cycles with fewer plastic items.
- Never cook food in plastic.

3. A growing number of cancer types are connected with exposure to PFAS - (per- and poly fluoroalkyl substances).

Per- and polyfluoroalkyl substances (PFAS) are a class of 10,000+ chemicals. These chemicals are used extensively in a variety of consumer and industrial products as they impart useful properties that repel water and grease/oil. PFAS are used in food packaging or cookware to keep food from sticking and in carpets and clothes to make them stain or water resistant. They are also used in cosmetics, such as waterproof mascara and in firefighting foams to make these retardants effective against fuel and chemical fires. PFAS are highly persistent in the environment and in our bodies, which is why they have been given the name of "forever chemicals." The most studied chemicals in the class are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). Both chemicals have been associated with developmental toxicity, immunotoxicity, and cancer. Although PFOA and PFOS are no longer produced in the U.S., because of their persistence in the environment, they are still ubiquitous throughout the U.S., particularly in drinking water.

What is the research telling us? CENSWPA first reported on PFAS in its first Year in Review in 2021 as research was beginning to accumulate regarding possible links to cancer. As the number of research studies have grown substantially, so do efforts to conduct meta-analyses – studies that statistically combine results from multiple studies to draw broader conclusions (see glossary of terms). However, rather than providing clarity regarding potential cancer risks, some of the meta-analyses published in 2024 were not able to decipher a clear direction of the evidence (positive or negative effects) in part due to differences in the methods used in the individual studies. This is particularly true for meta-analyses reviewing the state of the evidence for breast and thyroid cancers associated with PFAS exposure. For other cancer types, such as kidney, evidence from 2024 is strengthening prior knowledge regarding concern. And yet for others, such as brain, melanoma, and esophageal, research in 2024 is the first of its kind signaling the need for additional research to substantiate current findings.

- Breast cancer. Meta-analyses (see glossary of terms) published in 2024 vary in their conclusions on whether exposure to PFAS increases breast cancer risks. Yang and colleagues found an increase in breast cancer risk associated with one type of PFAS (PFDA) (Yang et al. 2024). However, two other meta-analyses found a lack of an association between any type of PFAS exposure and breast cancer risk (Jia et al. 2024; Chang et al., 2024). These latter two meta-analyses highlighted significant variations in how PFAS exposure was being measured. Because PFAS are known to be endocrine active and studies of such substances are highly sensitive to how exposure is assessed given particular windows of development, such as during puberty, Cheng and colleagues recommended improved exposure assessment techniques in future studies (Chang et al. (2024). Such a recommendation was justified by study findings demonstrating elevated risk when individual studies measured exposure levels prior to diagnosis and examined risk associated with certain breast cancer subtypes, especially hormone-receptor positive tumors that are more sensitive to endocrine active compounds (Chang et al. (2024).

- Kidney cancer. Kidney cancer was one of the first cancer types to be connected with exposure to PFAS based on the seminal study of communities impacted by severe contamination from the Dupont manufacturing facility in Parkersburg, West Virginia (Barry et al., 2013). Studies published in 2024 confirm this prior research linking PFAS exposure to kidney cancer. A study of communities in Italy that experienced dramatically high levels of PFAS in drinking water from industrial pollution found elevations in kidney cancer mortality (Biggeri et al. 2024). Another study confirmed exposure to PFAS (PFOA) and increased risk of kidney cancer (Winquist et al. 2024). A meta-analysis also confirmed increased risk associated with another type of PFAS (PFDA) for the class of genitourinary cancers, which is inclusive of kidney cancers (Yang et al. 2024).

- Thyroid cancer. PFAS are known to cause thyroid disrupting effects and thus have been a focus of thyroid cancer research over the last decade. Cellular and epidemiologic studies published in 2024 provide suggestive evidence of an association with exposure to PFAS (at least specific types) and thyroid cancer. For example, Coperchini and colleagues identified specific types of PFAS (PFOA and PFHxA) that are able to modify cellular factors creating a favorable environment for the development of thyroid tumors (Coperchini et al. 2024). A case control study examining PFAS serum levels found one specific type of PFAS (PFDA), increased the risk of thyroid cancer (Cirello et al. 2024). Despite these positive findings, a meta-analysis

published in 2024 examining the current literature fails to find clear evidence of increased risk of thyroid cancer associated with PFAS exposure (van Gerwin et al. 2024).

- **Childhood cancer.** One notable study in 2024 by Jones and colleagues examined risk of childhood cancer and exposure to PFAS. Blood serum levels of 19 different PFAS were measured in mothers during the first trimester of pregnancy. These levels were then examined in association with subsequent childhood cancer risk. Risk of acute lymphoblastic leukemia (ALL) – the most frequently diagnosed childhood cancer – was elevated in association with exposure to a type of PFAS (NMeFOSAA). This association was strongest among those diagnosed before the age of 5 years. Exposure to another type of PFAS (PFOA) was also linked to increased risk of ALL, but only among those samples collected during 1986-1995 when levels in products were the highest (Jones et al. 2024).

- **Other cancer types.** Other types of cancer linked to PFAS exposure have been less studied, but research published in 2024 is raising new concerns. For example, Moon and Mun (2024) investigated various cancer types linked to different PFAS exposures. Their study found elevated risks for several cancers, including esophageal cancer (associated with PFOA and PFOS), melanoma (linked to PFOA and PFHxS), prostate cancer (connected to PFOS and PFNA), and lung cancer (associated with PFOS and PFNA) (Moon and Mun 2024). A study of workers involved in the manufacturing of PFOS also revealed increased lung cancer risk along with non-statistically significant (see glossary of terms) elevated risk for bladder, colorectal, and pancreatic cancers (Alexander et al. 2024).

What can we do to reduce potential cancer risks associated with PFAS? The 2024 evidence highlights specific PFAS linked with increased cancer risks. Although studies focus on individual PFAS compounds, in reality, we are exposed to a vast mixture of PFAS in our drinking water, from exposure to soil, and in our consumer products like textiles, personal care items, and cookware. Over the past 25 years, scientists and regulators have learned that PFAS, as a whole chemical class, are problematic. When we regulate or phase out one type of PFAS, it is often replaced with another, which later proves to be harmful. As a result, regulatory agencies are starting to prohibit all PFAS. Many states (including Washington, California, Vermont, Maine, and Colorado) have prohibited PFAS as an entire class (i.e., all 10,000+ substances) in product categories such as carpets, textiles, food packaging, and ski waxes, among others (Safer States 2025). The European Commission has proposed a universal PFAS restriction – all uses of this class of chemicals should be prohibited (ECHA 2025).

These bans do not mean that we no longer have water resistant jackets or food packaging that resists leakages. Rather, industry actors have replaced PFAS with alternatives and are still providing society with the products and functionality they desire. Moreover, state policies are becoming increasingly sophisticated to demand that industry vet the intrinsic hazards of alternatives to ensure that they are safer.

Pennsylvania, however, is NOT among the states issuing these prohibitions. As such, the state risks being a dumping ground for PFAS products that have been banned elsewhere. A key risk reduction strategy for PFAS is simply to duplicate model policies that have been adopted in other states (Safer

States 2025) to ensure that products containing PFAS that pose a high risk of exposure to the public are prohibited.

4. Cancer severity and survival are impacted by exposures in our environment.

In recent years, there has been a growing body of evidence raising concern that chemicals in our environment increase the risk of developing cancer and may also worsen outcomes for cancer patients, potentially affecting survival rates.

What is the research telling us? Research described in CENSWPA's 2022 Year in Review highlighted a study by Clark and colleagues that found children living within 2 km of fracking activities in Pennsylvania experienced nearly a 2-fold risk of developing acute lymphoblastic leukemia compared to those living further from such activities (Clark et al. 2022). In 2024, research was published looking into the question of whether such exposures decrease the survival of children with cancer. Investigators examined children with cancer and found that those living within 1000 meters of an oil or gas well experience an increased risk of dying from acute myeloid leukemia as well as hepatoblastoma (a rare type of liver cancer) (Hoang et al. 2024). Hazards related to such activities are abundant and include exposures to a mixture of known carcinogens in drinking water as well as in ambient and indoor air (Hoang et al. 2024).

Over the years, CENSWPA has highlighted studies documenting air pollution exposure as problematic for those with cancer, including reduced survival rates among those with lung cancer (McKeon et al. 2022) and increased respiratory hospitalizations among childhood cancer patients (Ou et al. 2019). Published in 2024, a study revealed that air pollution exposure is also highly problematic for those in treatment for mesothelioma and asbestos-related lung cancer. Huh and colleagues found that survival rates for both cancer types decreased with increasing exposure to air pollution (Huh et al. 2024).

Also notable in 2024 was research looking at substitutes for PFAS that only further justify concerns regarding the whole chemical class. Hong and colleagues examined patients undergoing chemotherapy for pancreatic cancer who developed resistance to such therapy, specifically the use of Gemcitabine-based chemotherapy which is currently the most effective treatment for a disease that is highly aggressive (Hong et al. 2024). Their research uncovered that a type of PFAS (PFOS 6:2 Cl-PFESA) which is available as a substitute for one of the more widely used PFAS (PFOS) is highly problematic for those undergoing treatment for pancreatic cancer. Patients exposed to PFOS 6:2 Cl-PFESA experienced a reduction in the efficacy of Gemcitabine-based chemotherapy and thus an inability to halt the progression of the disease.

What can we do to reduce harm from toxic chemicals in our environment among cancer patients and survivors? People with cancer, including survivors, are at higher risk from harm when exposed to environmental carcinogens due to cumulative insults from the use of toxic agents used for treatments (e.g., chemotherapy and radiation) and the biological toll cancer takes on the body. However, most education and outreach for cancer patients focuses solely on medical care, often overlooking strategies to reduce exposure to harmful environmental toxins. This needs to change.

Cancer centers need to acknowledge the growing evidence and evolve their guidance to patients that includes risk reduction strategies related to avoiding harmful agents – such as refraining from being outside during high air pollution events. Moreover, the research evidence should be a **call to action** for medical institutions and advocacy organizations representing cancer patients and survivors because patients and their families are unable to fully protect themselves from these harms. Healthcare providers and health insurance providers may also be interested in ensuring their patients undergoing cancer treatment are not exposed to harmful agents, as these agents may limit the impact of the success of treatments, possibly leading to increased costs for the provider or insurer. It takes policy action to remedy systemic failures that have allowed chemicals to be used or released into our environments that increase cancer, affect quality of life among cancer survivors and reduce cancer survival rates. Although studies have documented the harms of environmental toxicants on cancer patients, this remains a largely under researched area. Greater attention from cancer researchers is needed to fully understand how these exposures impact survival among our loved ones and worsen outcomes for those battling the disease.

Conclusion

Once again, this Year in Review demonstrates that the evidence base related to risks associated with cancer and environmental exposures continues to gather strength. It also reinforces that effective cancer risk reduction strategies are both necessary and achievable. Upcoming changes in federal policy may limit or reduce regulation of industrial activities, possibly eliminating progress in reducing environmental cancer risks to date. Cancer, however, is not political. Most people's lives have been impacted by this disease. Thus, progress on prevention is still possible. No one wants to suffer or see a loved one go through the pain of experiencing and treating cancer.

Prevention requires us to pay attention to the science when there are signals of concern and to find alternative ways of achieving the same end. The availability of safer alternatives makes clear that prevention doesn't mean "doing without". It is technologically possible to substitute carcinogens with safer alternatives and still satisfy the products and societal functions needed.

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