

Environmental and Economic Strategies for Primary Prevention of Cancer in Early Life

David Kriebel, ScD, Polly J. Hoppin, ScD, Molly M. Jacobs, MPH, Richard W. Clapp, DSc

abstract This article summarizes the evidence for environmental toxic exposures contributing to cancers in early life, focusing on the most common cancer sites in this age group. It provides examples of widespread avoidable exposures to human carcinogens through air, water, and food and then describes recent examples of successful initiatives to reduce exposure to chemicals linked to these cancer sites, through government policy, industry initiatives, and consumer activism. State government initiatives to reduce toxic chemical exposures have made important gains; the Toxics Use Reduction Act of Massachusetts is now 25 years old and has been a major success story. There are a growing number of corporate initiatives to eliminate toxics, especially carcinogens, from the products they manufacture and sell. Another important opportunity for cancer prevention is provided by online databases that list chemicals, their toxicity, and lower-toxicity alternatives; these can be used by businesses, health care institutions, consumers, and workers to reduce exposures to chemicals of concern. The article concludes by inviting pediatricians and public health professionals to include elimination of carcinogen exposures in their work to promote primary prevention of cancer in early life.

Cancer prevention remains a pressing national need, given the substantial and ongoing health and economic toll of the disease. The articles in this supplement of *Pediatrics* emphasize childhood as an important time for cancer prevention research and interventions. In this article, we focus on primary prevention: preventing the disease from developing. We believe that primary cancer prevention across the population deserves increased attention and funding because, with a few important exceptions, cancer incidence rates continue to rise.¹ Among adults (and in particular among men), smoking-related cancers have fallen over the past decades. But beyond this important success, the picture is much bleaker; the incidence rates of cancer in adults at many sites, including non-Hodgkin lymphoma, kidney, thyroid, and liver cancer, continue to rise. Indeed,

Lowell Center for Sustainable Production, University of Massachusetts Lowell, Lowell, Massachusetts

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Address correspondence to David Kriebel, ScD, Department of Work Environment, University of Massachusetts Lowell, 1 University Ave, Lowell, MA 01854. E-mail: david_kriebel@uml.edu

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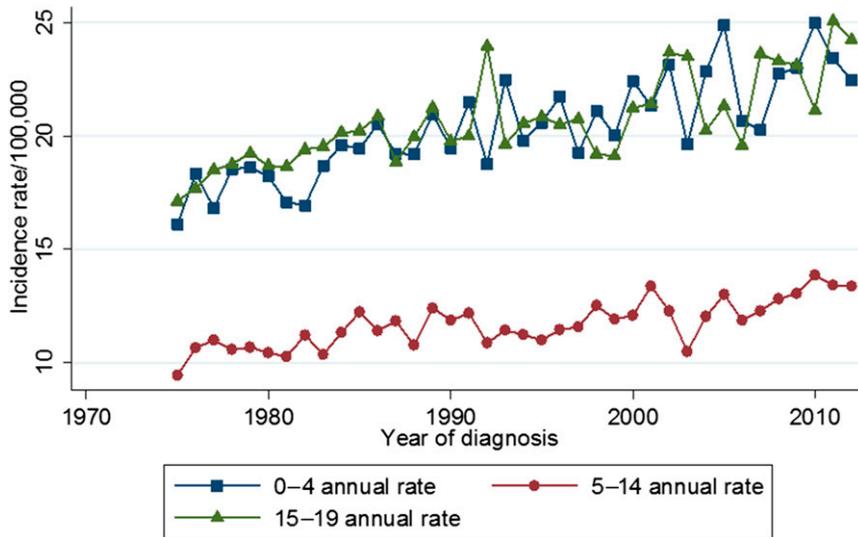


FIGURE 1 Childhood cancer incidence in the United States. Surveillance, Epidemiology, and End Results data for all cancer sites combined, both sexes, in 3 age groups, 1975–2012.

the overall incidence of cancers not related to smoking has risen substantially over the past 25 years.¹

Among children, cancer incidence rates have risen steadily since data were first gathered systematically in the 1970s (Fig 1).² Figure 1 shows the incidence rates for all cancer sites combined for children in the Surveillance, Epidemiology, and End Results Program registries from 1975 to 2012. These data are drawn from cancer registries covering a sample of the general population that is representative in sex, race, and age.² The increase in incidence is remarkably similar among infants (ages 0–4) and among teenagers (ages 15–19), whereas the rates in the middle years are lower and rising only slightly. Siegel et al³ recently reported that the overall cancer incidence rate in the years 2001 to 2009 was rising among African American children more rapidly than among white children. Fortunately, improved treatments are reducing cancer mortality among children. But cancers are better prevented than treated; treatment is traumatic, costly, and toxic.⁴ Cancer survivors carry long-term consequences, including secondary

cancers, cardiovascular disease, and neurobehavioral impacts, among others.⁵

What is causing these rises in cancer incidence? Cancers are diverse diseases with diverse causes, and it would be a mistake to presume that there is a single driver. Yet there is growing evidence that certain chemical exposures cause cancer and that these chemicals are widespread in air, water, food, soil, and consumer products.⁶ Particularly for children, whose exposure to the well-established “lifestyle” risk factors, tobacco and alcohol, is low, chemicals in the environment probably play an important role in the rising incidence trends.^{7,8}

Much of the evidence about linkages between environmental contaminants and cancer is from the workplace, and so it necessarily focuses on adults. Occupational exposures to a range of chemicals have been associated with bladder, lung, kidney, and other cancers.^{9,10} Workplace exposures are risk factors for children as well, via several routes of exposure including chemicals brought home on clothing and through damage to sperm or crossing the placenta during pregnancy.

Moreover, some workplace chemicals associated with cancer are also found in home, school, and community settings. Evidence that exposures to pollutants outside the workplace are contributing to the cancer burden is growing. For example, it was recently estimated that diesel exhaust alone may account for 6% of all lung cancers in the United States and the International Agency for Research on Cancer (IARC) recently established that exposure to outdoor air pollution and to fine particulate matter in outdoor air are known causes of human lung cancer.^{11,12} There is also a growing literature linking near-roadway exposure to traffic with childhood leukemias.¹³

Cancer is largely a disease of old age, but in modern societies, exposures to environmental carcinogens begin early in life. The latency period between exposure to a carcinogen and clinical onset of cancer may be as short as months in the case of some childhood cancers but much longer for most adult cancers. There are important but still limited data demonstrating that exposures to chemical carcinogens and radiation during the critical developmental periods of gestation, childhood, and adolescence can lead to cancers much later in life.^{8,14,15}

The underlying causal web for exposures in childhood that lead to cancer later in life is undoubtedly complex, and we may never arrive at a definitive understanding of all the causes and their relative importance. But in our view, the unexplained and striking increases in childhood cancer incidence rates (Fig 1) and the steady increases in some adult cancers with strong links to chemical exposures such as non-Hodgkin lymphoma and kidney cancer, noted earlier, justify a call to take steps now to prevent carcinogen exposures, beginning in childhood.

Some steps can be taken at the individual level, by eliminating

exposure to environmental tobacco smoke or selecting clothing, toys, soaps and shampoos, and food that do not contain hazardous chemicals, although it is important to note that people disproportionately exposed to pollutants often have less financial capacity to make what are sometimes expensive purchases. Other steps must occur at the societal level, to restrict pollutants and drive the design and scaling of safer materials, products, and processes.

How important will reducing exposure to environmental and occupational carcinogens be in cancer prevention, particularly for children? The honest answer is that we do not know. But we may not need to know, at least not precisely. There is economic opportunity in the production of safer materials, products, and processes, particularly as demand increases. Health care professionals and the institutions they work for have an important role to play in driving this demand. In this article we describe a range of policies and programs that aim to discourage the use of toxic chemicals and increase the use of safer products and services. We argue that these policies and programs should be supported and expanded as essential elements of primary cancer prevention.^{16,17}

CHEMICAL CARCINOGENS, KNOWN AND UNKNOWN

Since 1971, IARC has evaluated and published critical reviews of chemicals, physical agents, and conditions of exposure for carcinogenicity.¹⁸ In assigning substances or conditions to 1 of 5 classifications, based on expert judgment about the weight of evidence for carcinogenicity, the IARC considers evidence from epidemiologic studies, studies in experimental animals, and mechanistic information. Of the nearly 1000 reviews conducted to date, the IARC rated 118 as

“carcinogenic to humans,” 75 as “probably carcinogenic to humans,” and 288 as “possibly carcinogenic to humans.” Roughly half (503) were judged to be not classifiable, usually because of insufficient evidence, and just 1 substance was found to be “probably *not* carcinogenic to humans.”¹⁸

Siemiatycki et al⁹ concluded that nearly half of the substances and exposure conditions classified by IARC as known or suspected human carcinogens are found in occupational settings. Examples include asbestos, benzene, tobacco smoke (including secondhand smoke), nonarsenical insecticides, chemicals used in dry cleaning, and X- and γ -radiation, among many others. As noted earlier, all these exposures may affect children, either through in-home exposures, parents bringing substances home on clothing, exposures at conception or in utero, or community pollution from factory emissions. A recent review article outlined 10 common workplace carcinogens to which children are exposed daily, including benzene, 1,3-butadiene, dioxins, and polycyclic aromatic hydrocarbons.⁸

One important example of environmental chemicals causing childhood cancer is pesticides.^{19,20} A recent meta-analysis by Chen et al²⁰ of pesticide exposures and childhood cancers found good evidence for significantly higher risks of leukemia and lymphoma from exposures to indoor residential insecticides. There was also evidence, although somewhat weaker, for a link between childhood brain cancer and home pesticide or herbicide exposures.

There is good evidence that chemicals other than pesticides also increase the risk of childhood cancers.^{8,21} Table 1 lists environmental exposures that have been linked to 2 common groups of cancers of childhood: leukemias and non-Hodgkin lymphoma.²²

Exposures during critical windows of development can affect not only childhood cancers but also cancers later in life. Recent research by Cohn et al¹⁵ demonstrated that exposure to DDT (a known endocrine disruptor) in utero resulted in a nearly fourfold increase of breast cancer later in life. Exposure during puberty, when the breast tissue is undergoing significant developmental changes, resulted in a fivefold increase in breast cancer later in life.¹⁴ Studies examining early life exposures to radiation, polycyclic aromatic hydrocarbons, and endocrine-disrupting compounds such as diethylstilbestrol have observed similar elevated risks of cancer later in life.^{8,23}

These studies probably elucidate only a small fraction of the environmental cancer risks because only a small percentage of the >30 000 chemicals in use has been adequately tested for carcinogenicity.²⁴ And to make matters worse, the development of new chemicals is outpacing the capacity of government agencies to test them.²⁵

Recent insights into carcinogenesis add challenges to the problem of identifying chemical carcinogens. Cancer has long been understood to be a multifactorial, multistage disease where multiple pathways or “hallmarks” are necessary for the disease to develop.²⁶ Although this insight is not new, it has recently led to the hypothesis that chemicals that do not in themselves cause cancer (they will be negative when tested in a standard rodent cancer feeding study) may nevertheless contribute to cancer by influencing individual cancer hallmarks. Evidence from the recent Halifax Project suggests that dozens of chemicals considered “non-carcinogens” interact or interfere with these cancer hallmarks at environmentally relevant levels of exposure.²⁷ These findings provide important clues about how common and widespread chemicals

TABLE 1 Examples of Environmental Exposures Linked to 2 Common Cancers of Childhood²²

Exposures Associated With Childhood Leukemias
Carbon tetrachloride
Chlorinated solvents
Ionizing radiation
Metal dusts
Specific pesticides
Secondhand tobacco smoke
Trichloroethylene
Exposures Associated With Non-Hodgkin Lymphoma
1, 3-butadiene
Aromatic amines
Carbon disulfide
Carbon tetrachloride
Chlorophenols
Creosotes
DDT and dichlorodiphenyldichloroethylene
Dioxins and 2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
Ionizing radiation
Organochlorine pesticides
Organophosphate pesticides
Polychlorinated biphenyls
Phenoxyacetic acid herbicides
Secondhand tobacco smoke
Solvents
Tetrachloroethylene
Trichloroethylene
Exposures with at least "good" evidence for an association are shown.

to which children are exposed in their environment may affect cancer mechanisms. Although most animal and epidemiologic studies of cancer focus on single carcinogens, these findings also elevate the importance of how mixtures of chemicals may act collectively and synergistically to affect cancer development and raise the possibility that eliminating exposure to these noncarcinogens might also reduce the cancer burden.

HOW IMPORTANT ARE TOXIC CHEMICALS IN THE CANCER EPIDEMIC?

It is difficult to quantify the contribution of environmental and occupational exposures to the cancer burden because of the multifactorial nature of the disease. The effects of mixed exposures, gene–environment interactions, windows of special vulnerability such as prenatal trimesters, and

different combinations of risk factors make such estimates particularly uncertain. But even conservative estimates add up to a large number of cancers and, for some cancer sites, a high proportion. For example, the American Lung Association estimates that radon exposure in homes, schools, and other buildings is the second leading cause of lung cancer in the United States (<http://www.lung.org/our-initiatives/healthy-air/indoor/indoor-air-pollutants/radon.html>) and is “responsible for an estimated 21,000 deaths annually in the United States.” Rushton et al’s²⁸ conservative estimate of the occupational cancer burden in the United Kingdom attributed 5% of all cancer deaths to workplace exposures (8% among men).

In 2002, Landrigan et al²⁹ convened an expert panel to estimate the environmental attributable fraction for childhood cancer. The panel reviewed the evidence and found that there were insufficient data to assign a “best estimate,” and they concluded that the environmental attributable fraction was at least 5% and <90%, but they were not able to narrow this broad range with available evidence. But even taking the low end of this range, a significant number of the >7000 childhood cancer cases occurring annually in the United States are potentially preventable through reducing chemical exposures.²⁹

The President’s Cancer Panel summarized its year-long assessment of the impacts of environmental causes of cancer by concluding, “The true burden of environmentally induced cancers has been grossly underestimated.”⁶ The World Health Organization has reached a similar conclusion and called for actions to address the problem. Signatories to the 2011 Asturias Declaration³⁰ agreed that “there is a need to create a global strategic framework for control of environmental and occupational carcinogens that

enables and promotes primary prevention more broadly.”

Society’s ability to address the concerns of patients and their families and to accurately quantify the contribution of environmental exposures to childhood cancer is stymied by a lack of investment in relevant research. Most of the \$4.95-billion National Cancer Institute budget for 2015, which has been at about this same level (not adjusted for inflation) since 2005, is focused on clinical trials and treatment centers aimed at finding cures for cancer or extending survival, not on primary prevention (<http://www.cancer.gov/about-nci/budget>). According to Zachek et al,³¹ only 3% to 7% of all National Institutes of Health funding on childhood leukemia was focused on environmental etiologies (2010–2011), and the National Cancer Institute devoted only 1% of its funding for childhood cancer to environmental risks.

Health care professionals are among those wanting more information about links between environmental chemicals and childhood cancer. A recent survey of pediatric oncologists and nurse practitioners reported that a majority (61%) believed that environmental exposures were important contributors to childhood cancer. And a large majority (88%) reported receiving questions from families about environmental exposures.³¹ But at the same time, many (44%) did not feel comfortable talking with their patients about environmental links with disease, and most (92%) said they would like to have more information on this topic.

TOXICS USE REDUCTION IS A POTENTIALLY POWERFUL CANCER PREVENTION STRATEGY

Despite many research gaps, we do know that cancer can be prevented by reducing carcinogenic exposures.

The best example is the recent decline in lung cancer after declining prevalence of cigarette smoking in the United States. According to 1 estimate, “Nearly 40% of reductions in male lung cancer deaths between 1991 to 2003 can be attributed to smoking declines in the last half century.”³² Similarly, there is strong evidence that the control of asbestos exposure at work has decreased the mesothelioma incidence rate in the United States by 1.5% per year (2003–2012).² And some authorities suggest that healthy eating may reduce the overall cancer burden by 5%.³³ These successes, along with the evidence on links between environmental and occupational chemicals and cancer, underlie the President’s Cancer Panel’s recommendation to “remov[e] carcinogens and other toxins from our food, water, and air that needlessly increase healthcare costs, cripple our nation’s productivity and devastate American lives.” The report concludes, “A precautionary prevention-oriented approach should replace current reactionary approaches to environmental contaminants in which human harm must be proven before action is taken to reduce or eliminate exposure.”⁶

Although the challenge of eliminating exposure to carcinogens may appear daunting, a range of effective interventions is under way. Examples of successful actions to reduce carcinogenic exposures include initiatives by state governments, industries, and nongovernment organizations (NGOs).

State Initiatives

In 1989, Massachusetts passed landmark legislation, the Toxics Use Reduction Act (TURA), which began to be implemented in 1990.³⁴ The law was remarkable for several reasons. First, it passed the state legislature by unanimous vote. Second (and probably related to its strong political support), the TURA

does not compel toxic chemical users to control or eliminate chemicals. It does require them to report their use of certain chemicals to the state and plan for the reduction of those chemicals. But companies are not required to follow the plans. In practice, many do follow through on the replacement or reduction of chemicals, including carcinogens. The law has been highly successful; it has reduced toxic chemical use dramatically, it has been well accepted by industries, and funding for the law has been regularly renewed in the legislature.

An assessment of the first 20 years of TURA found that the use of carcinogens by Massachusetts industries declined 32%, and the environmental releases of carcinogens declined 92% (Table 2).³⁵

Analyses of economic activity in the relevant industries indicate that these reductions were not due to industries leaving the state or reducing productivity.

Inspired by Massachusetts, other states have enacted policies restricting use of chemicals in recent years. Many of the laws are narrower than the TURA, and they typically focus on a single chemical or class of chemicals. For example, 32 states have enacted or proposed legislation to ban mercury in products, 12 states have enacted laws to prohibit polybrominated diphenyl ethers in products, and 14 states have enacted laws to ban lead in various products.³⁶ Additional state laws prohibit chromated copper arsenate as a wood preservative and phthalates, bisphenol A, perchloroethylene, and formaldehyde in various products. A few states have taken a broader approach to chemical management, such as the Washington Children’s Safe Products Act of 2008,³⁷ the Maine Act to Protect Children’s Health and the Environment From Toxic Chemicals in Toys and Children Products of 2009,³⁸ and the Minnesota Toxics

TABLE 2 Known and Suspected Carcinogens With >90% Declines in Environmental Releases From Massachusetts Industries, 1990–2010³⁵

Chemical	% Change
Cadmium and compounds	94
Chromium and compounds	95
Diethyl hexyl phthalate	96
Ethylene oxide	96
Formaldehyde	91
Methylene chloride	98
Toulene diisocyanate	96
Trichloroethylene	96
Perchloroethylene	95

Free Kids Act of 2010.³⁹ These 3 laws all target children and argue for a more precautionary approach to chemical safety for children’s products because of the heightened vulnerability of children to many toxic chemicals, including carcinogens.

Alternatives Assessment and Green Chemistry

While concern about carcinogens and other toxic chemicals has increased pressure to replace them, concern has also increased about regrettable substitutions, replacing 1 toxic chemical with another of equal or even higher hazard. As a consequence, there is growing interest in the use of alternatives assessment to identify safer solutions^{40,41} and in green chemistry, a new chemistry of safer materials to replace the hazardous substances that are in widespread use.⁴²

As biologist Mary O’Brien⁴³ noted, “One of the most essential, and powerful steps to change is understanding that there are alternatives.” Alternatives assessment is a process for identifying, comparing, and selecting safer alternatives to chemicals of concern on the basis of their hazards, performance, and economic viability.⁴⁰ A primary goal of an alternatives assessment is to reduce potential harm to human health and the environment by identifying and

adopting a safer chemical to achieve a specific function (eg, solvency, electrical conduction) for a given application. Many public and private organizations in the United States and Europe have developed methods and tools for evaluating alternatives,⁴⁰ and just last year, the National Research Council issued its own alternatives assessment guidance.⁴⁴ Dozens of alternatives assessments have been conducted and published, including those resulting from governmental programs such as the US EPA's Design for Environment/Safer Choice Program or regulatory actions by government agencies such as the European Chemicals Agency.^{45,46} Several state programs have also published alternatives assessments on a wide range of toxic chemicals for specific applications.³⁶ Use of alternatives assessment in the United States is expected to increase, given the requirements of California's Safer Consumer Products Regulation, which requires alternatives assessments to be conducted for chemical-product combinations that the state identifies as a high concern.⁴⁷

The long-term key to the elimination of chemicals that contribute to cancer is green chemistry, defined by its principal architects, Paul Anastas and John Warner, as "the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products."⁴² Five of the 12 principles underlying green chemistry are as follows:

- Design chemicals and products to be effective with little or no toxicity.
- Prevent waste that requires treatment or cleanup.
- Develop less hazardous ways to synthesize chemicals.

- Use renewable raw materials.
- Design chemicals to break down after use.

Green chemistry is responding to the demand for safer materials and creating economic opportunity by stimulating a new stream of materials research, development, and production. The California Green Chemistry Initiative aims to implement these principles and encourage businesses to comply with greener production processes (<https://www.dtsc.ca.gov/PollutionPrevention/GreenChemistryInitiative/>). As expected, this has led to innovation, broader requirements for the conduct of alternatives assessment, and the beginning of a green economy in the state.

Online Hazard Information Databases and Applications

A growing number of online databases with information about the toxicity of chemicals and safer alternatives are important tools for cancer prevention through toxics use reduction. These databases are being developed by corporations and NGOs, sometimes in collaboration.⁴⁸ Walmart, for example, now requires its suppliers to evaluate the chemicals they use against an online toxicity database. If there are toxic chemicals in the products suppliers sell to Walmart, they are expected to either eliminate the hazards or tell Walmart when a listed hazard is being used and why. The use of hazard information (eg, the inherent toxicity of a chemical) rather than reliance on a risk assessment, in which likely exposure is combined with hazard to generate a quantitative estimate of risk, reflects a sea change in approach to chemical management. Walmart and other companies are seeking to eliminate risk by eliminating hazard, rather than by minimizing exposure, which is often much more difficult to control.

Table 3 lists useful hazard databases and professional and consumer-oriented tools that provide information about hazards and safer options. Although they do not cover all chemicals or products, and they draw on data that are inherently limited, these resources are facilitating greater public awareness and, as a result, individual-level prevention.

Corporate Initiatives

Corporations are increasingly taking steps to identify and eliminate carcinogens and other toxics from their supply chains, without waiting for government regulations to require such actions. Some examples of these activities are as follows:

- The Green Chemistry and Commerce Council is a collaboration of ~70 firms, hosted by the Lowell Center for Sustainable Production at the University of Massachusetts Lowell (<http://www.greenchemistryandcommerce.org/>). Through the Green Chemistry and Commerce Council, product manufacturers such as Nike, Johnson and Johnson, and Herman Miller, retailers such as Target and Staples, and chemical companies such as BASF and DuPont are working to mainstream and advance green chemistry throughout the supply chain.
- Corporate chemical restriction policies. Many leading US product manufacturers have developed corporate restricted substance lists of chemicals to be avoided.²⁴ Some health care institutions have targeted particular chemicals and are developing strategies for replacing them, including mercury thermometers, polyvinyl chloride, and phthalates, and are actively engaged in processes for identifying and eliminating exposure to toxics.

TABLE 3 Examples of Chemical Hazard Information Resources (Not Comprehensive)

Hazard Resource Name	Web Link	Description
ChemHAT: Chemical Hazard and Alternatives Toolbox	www.chemhat.org	ChemHAT, a publicly available tool developed by BlueGreen Alliance, a group of labor unions and environmental organizations, provides information about chemicals commonly found in workplaces including health effects, regulatory status, environmental impacts, sources of exposure, and available alternatives. The information is presented in a simple color-coded format.
Good Guide	www.goodguide.com/	Founded at the University of California at Berkeley and now a division of Underwriters Laboratories, the Good Guide is a Web site and mobile app that provides information about chemicals in >250 000 consumer products, allowing consumers to select lower-hazard products.
GreenScreen for Safer Chemicals GreenScreen for Safer Chemicals List Translator	www.greenscreenchemicals.org/	GreenScreen is a tool developed by an NGO, Clean Production Action, which helps users conduct chemical hazard assessments. Completed GreenScreen assessments of chemicals are also available, providing hazard profiles of chemicals across 18 human and nonhuman health end points. The GreenScreen List Translator links users to authoritative hazard screening lists.
Skin Deep	www.ewg.org/skindeep/	A Web site and mobile app developed by an NGO, the Environmental Working Group, provides hazard information and ratings for 64 000 beauty products and cosmetics helping consumers select lower-hazard products.

- Supplier compliance programs. Some major brand-name consumer product manufacturers have active compliance and training programs with foreign suppliers to avoid restricted chemicals and to disclose chemicals in products in the supply chain.
- Corporate hazard screening systems. S.C. Johnson & Son, previously known as Johnson Wax, has developed the “GreenList” for rating chemical ingredients against a set of criteria (<http://www.scjohnson.com/en/commitment/focus-on/greener-products/greenlist.aspx>). In its “Considered Chemistry” Program, Nike is using a “positive list” of preferred chemicals that are not listed as harmful to human health or the environment (<http://www.nikeinchemistry.com/sustainable-and-green-chemistry>).

CONCLUSIONS

The 2010 President’s Cancer Panel stated,

“It is more effective to prevent disease than to treat it, but cancer prevention efforts have focused narrowly on smoking, other lifestyle behaviors and chemopreventive interventions. Scientific evidence of individual and multiple environmental exposure effects on disease initiation and outcomes, and consequent health system and societal costs, are not being adequately integrated into national policy decisions and strategies for disease prevention.”⁶

This article has described briefly both the need and opportunities for reducing exposures to environmental and occupational carcinogens as an important component of childhood cancer prevention.

Clinicians can begin to act on this information in a variety of ways. Useful information and training are available via the network of

Pediatric Environmental Specialty Units (<http://www.cdc.gov/features/pehsu/>) in the United States and via continuing education, webinars, and other programs sponsored by professional organizations such as the American Academy of Pediatrics. NGOs such as the National Environmental Education Foundation (<http://www.neefusa.org/>) and the Children’s Environmental Health Network (<http://www.cehn.org/>) have created environmental health history forms and patient education materials. Several of the public access databases cited in this article can be added to clinicians’ toolboxes when working with patients to reduce their exposure to hazardous chemicals.

Clinicians have a role to play in cancer prevention at the individual and societal levels.^{49,50} Above all, political will is needed; the health care community can be particularly persuasive in arguing that we should not intentionally put chemicals we know contribute to cancer into our air, water, food, homes, schools, and workplaces. Of course, actions in this direction can be complex. To be effective, we will need to engage in systems analysis, identifying who benefits from the status quo, which dynamics are moving in the right direction but need to be scaled up, and from there selecting strategies to weaken the cycles that reward the use of toxic chemicals and strengthen the cycles that promote safer materials, products, and processes.

Health care institutions (eg, hospitals, health care suppliers, pension fund investors, insurance agencies) also have important roles to play in driving the development of and demand for safer alternatives, as do businesses, cancer charities, consumer organizations, schools, and many other groups (<https://noharm.org/>). Among all the stakeholders, nurses and doctors are trusted messengers. We call on them to engage in both individual- and societal-level primary prevention,

to educate families about smoking cessation programs for parents and about organic food and toxin-free products. Concerned clinicians can also advocate for smoke-free home policies in public housing, clean air in our cities, the elimination of carcinogens in children's toys, and ultimately for a "cancer-free economy" (<http://jptransition.org/2015/01/25/cancer-free-economy/>).

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ABBREVIATIONS

IARC: International Agency for Research on Cancer
 NGO: nongovernment organization
 TURA: Toxics Use Reduction Act

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