

Chemicals and Our Health:

Why Recent
Science is a
Call to Action



Safer Chemicals
Healthy Families

Acknowledgments

This report is the result of a collaborative effort of the Safer Chemicals, Healthy Families coalition, a campaign dedicated to protecting American families from toxic chemicals. The report incorporates a significant body of peer-reviewed science on chemicals and health. In addition, this report builds upon a previous report titled *The Health Case for Reforming the Toxic Substances Control Act* published in 2009.

For more information on our campaign, please visit our website at www.saferchemicals.org.

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Contents

| | |
|---|----|
| Executive Summary | 3 |
| Introduction | 4 |
| Cancer | 5 |
| Learning and Developmental Disabilities | 9 |
| Alzheimer's and Parkinson's Diseases | 12 |
| Reproductive Health | 15 |
| Asthma | 18 |
| Reducing Our Health Care Costs | 20 |
| Conclusion | 21 |
| Endnotes | 22 |

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Executive Summary

Agreement is growing across the political spectrum and among scientists, health professionals, and concerned parents that federal law does not adequately protect Americans from toxic chemicals. The primary law responsible for ensuring chemicals are safe—the Toxic Substances Control Act (TSCA)—was passed in 1976 and has never been updated. The law is so weak that the U.S. Environmental Protection Agency (EPA) has only been able to require testing on less than two percent of the more than 80,000 chemicals that have been on the market at some point since TSCA was adopted.¹

Much has changed since TSCA became law decades ago. Scientists have developed a more refined understanding of how some chemicals can cause and contribute to serious illness, including cancer, reproductive and developmental disorders, neurologic diseases, and asthma.

By reforming TSCA, we can reduce our exposure to toxic chemicals, improve our nation's health, and lower the cost of health care. This report documents some of the scientific findings and economic analysis in support of meaningful TSCA reform.

Chronic disease: many trends are on the rise

More than 30 years of environmental health studies have led to a growing consensus that chemicals are playing a role in the incidence and prevalence of many diseases and disorders in the United States, including:

- **Leukemia, brain cancer, and other childhood cancers**, which have increased by more than 20% since 1975.²

- **Breast cancer**, the incidence of which went up by 40% between 1973 and 1998.³ While breast cancer rates have declined in recent years in post-menopausal white women, rates of breast cancer in pre-menopausal white women and post-menopausal black women remain unchanged.^{4,5} A woman's lifetime risk of breast cancer is now one in eight, up from one in ten in 1973.⁶
- **Asthma**, which approximately doubled in prevalence between 1980 and 1995 and has continued to rise. In 2009, nearly 1 in 12 Americans had asthma.^{7,8}
- **Difficulty in conceiving and maintaining a pregnancy** affected 40% more women in 2002 than in 1982. From 1982 to 1995, the incidence of reported difficulty almost doubled in younger women, ages 18–25.^{9,10}
- **The birth defect resulting in undescended testicles** (cryptorchidism) increased sharply between 1970 and 1993, with uncertain trends since then.¹¹
- **Learning and developmental disabilities**, including autism and attention deficit hyperactivity disorder, affect nearly one in six U.S. children, as of 2008.¹² Between 1997 and 2008, the prevalence of autism increased nearly 300% nationally.¹³

According to the U.S. Centers for Disease Control and Prevention (CDC), 133 million people in the U.S.—almost half of all Americans—are now living with these and other chronic diseases, which account for 70% of deaths and 75% of U.S. health care costs.¹⁴

In general, these and other common diseases or disorders are the result of many factors, but many

chemicals, by themselves or in combination with other chemical and non-chemical factors, can be harmful to multiple systems in the body, increasing the risk of adverse health outcomes.

The health and economic benefits of reforming chemical policy

Estimates of the proportion of the disease burden that can be attributed to chemicals vary. A recent World Health Organization review conservatively estimates that the global disease burden related to chemicals is more than 8%.¹⁵ Here in the United States, researchers estimate that 5% of childhood cancer and 30% of childhood asthma are attributable to chemical exposures.^{16,17}

Whatever the actual contribution of chemicals to the overall disease burden or specific diseases, effective chemical policy reform will incorporate the last 30+ years of science to reduce those exposures that contribute to chronic disease and provide incentives to move to safer alternatives. Any decline in the incidence of chronic diseases also can be expected to lower health care costs.

The U.S. now spends over \$7,000 per person per year directly on health care.¹⁸ This sum does not include the cost of additional impacts, such as the costs of educating children with learning disabilities or emotional costs to a family coping with a mother's breast cancer diagnosis. Chemical policy reform holds the promise of reducing the economic, social, and personal costs of chronic disease by creating a healthier future for all Americans.

Introduction

Consensus is growing among scientists, health care providers, health and environmental advocates, consumer product manufacturers, and even some in the chemical industry, that when it comes to protecting Americans from toxic chemicals, current law has not kept up with the times.

The primary chemical safety law, the Toxic Substances Control Act of 1976 (TSCA), “grandfathered” in all chemicals that were in existence prior to 1976, not requiring any safety testing in order for them to remain on the market. Because of weaknesses in the law, in the thirty-six years since TSCA was enacted, the U.S. Environmental Protection Agency (EPA) has been able to require testing on less than two percent of the more than 80,000 chemicals that have been on the market at some point since TSCA was adopted.

Much has changed since 1976: chemical production volumes have increased rapidly, chemicals have become more pervasive in daily life, and scientists have developed

a more thorough understanding of how people are exposed to chemicals and how exposures can contribute to serious illness, including cancer, learning and developmental disabilities, neurological diseases, reproductive disorders, and asthma.



Many health professional organizations from across the country are expressing concern with the inadequate health protections afforded by current law. The American Medical Association, National Medical Association, American Academy of Pediatrics, American Nurses Association, and American Public Health Association have called on the U.S. Congress to fundamentally restructure TSCA such that it better protects public health and the environment.

Making the health care case for reform

We know that many chronic diseases are the result of multiple, interacting risk factors. Exposures to chemicals are among them—along with inadequate nutrition, lack of exercise, infection, challenging social and economic condi-

tions, age, tobacco use, and genes that can increase susceptibility to disease. The interplay of variables begins before conception and continues for an entire lifetime.¹⁹ The good news is that chemical exposures are among the risk factors that we can do something about.

By reforming TSCA, we can reduce exposure to toxic chemicals, improve our nation’s health, and lower health care costs.

This report summarizes some of the peer-reviewed, scientific studies showing that chemical exposures contribute to the growing burden of chronic disease in our country and offers an analysis of the economic benefits of reform.

Specifically, we summarize the growing scientific literature linking chemical exposures to five categories of chronic conditions that impact the daily lives of millions of Americans:

- Certain types of cancer
- Learning and developmental disabilities
- Alzheimer’s and Parkinson’s diseases
- Reproductive health and fertility problems, and
- Asthma.

This report also incorporates the results of published studies that estimate the proportion of our disease burden that is attributable to chemical exposures and the potential health cost savings from improved protection from toxic chemicals.



Cancer

Cancer affects millions of American families and adds billions of dollars to our nation's annual health care bill.

According to the National Cancer Institute, almost 45% of men and 38% of women in the United States will be diagnosed with cancer at some point in their lives.^{20,21} Cancer is the second most common cause of death in the U.S., exceeded only by heart disease.²² Nearly 1 out of every 4 deaths in the United States is caused by cancer.²³

Over the past two decades, the rates of some cancers have risen significantly. These include:²⁴

- Kidney, liver, thyroid, esophageal, and testicular cancer, as well as melanoma in men;
- Non-Hodgkin's lymphoma, Hodgkin's disease, melanoma, and cancers of the thyroid, liver, and kidney in women; and
- Childhood cancers overall, especially childhood leukemia and brain cancer (see Figure 1).

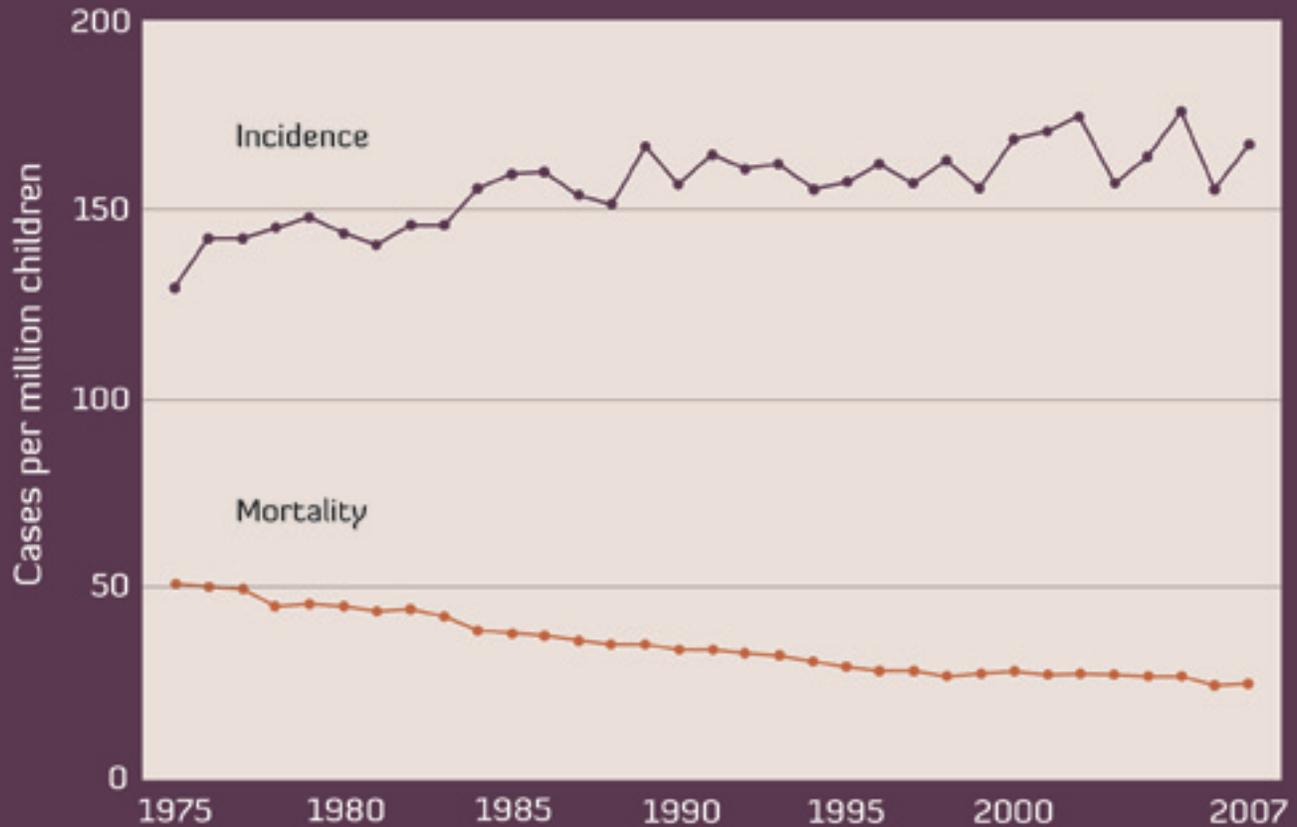
In 2010, the direct medical costs of cancer were \$102.8 billion and the overall costs were \$263.8

billion.²⁶ Medical costs for pediatric cancers in 2008 totaled an estimated \$1.9 billion.²⁷

The link to chemical exposure

Much of what we know about chemicals and cancer comes from experimental laboratory studies, long-term follow up of workers exposed to chemicals in their place of employment, and epidemiologic studies in communities where residents are exposed to hazardous substances. Laboratory animal studies are generally considered relevant for predicting toxic effects

Figure 1 - Cancer Incidence and Mortality for Children Under 20



SOURCE: U.S. EPA. America's Children and the Environment. www.epa.gov/envirohealth/children

DATA: National Cancer Institute, Surveillance, Epidemiology and End Results Program

Cancer is the second most common cause of death for Americans under the age of 20. The incidence of childhood cancer increased more than 20% between 1975 and 1990. Since 1990, the incidence has remained roughly at this elevated rate. Mortality declined substantially during this period, due largely to improvements in treatment.²⁵

of chemicals in people, with certain exceptions.

The U.S. Department of Health and Human Services relies on these types of studies to develop and periodically update its Report on Carcinogens. The 12th edition of the report lists over 200 chemicals as known human carcinogens, such as formaldehyde, asbestos, hexavalent chromium, and vinyl chloride, or reasonably anticipated to be human carcinogens, such as trichloroethylene (TCE), methylene chloride (dichloromethane), styrene, and 1,4-dioxane.²⁸ Subsequent to

the publication of the 12th edition, EPA officially concluded that trichloroethylene (TCE) is "carcinogenic in humans for all routes of exposure," noting that there is substantial potential for human exposure as TCE is widespread in ambient air, indoor air, soil, and groundwater.²⁹ The classifications of these and the other chemicals listed in Table 1 are largely based on studies of similarly exposed and diagnosed workers.

Despite being classified as known or probable carcinogens, many of these chemicals remain nearly

ubiquitous in the environment where people are easily exposed. For example, formaldehyde is a common indoor air contaminant because of its use in furniture, cabinets, countertops, insulation, wallpaper, paints, and paneling. It is present in a wide variety of other consumer products, such as antiseptics, medicines, cosmetics, dishwashing liquids, fabrics and fabric softeners, shoe-care agents, carpet cleaners, glues and adhesives, lacquers, paper, coatings, and plastics.³⁰ In a 2009 California study, nearly all new single-family

homes had indoor formaldehyde concentrations that exceeded guidelines for cancer and chronic lung irritation.³¹

Trichloroethylene is present in some paint removers, adhesives, rug cleaners, metal cleaners, pepper sprays, and spot removers.³² TCE has been detected in ambient air, surface water, and groundwater and is one of the most common contaminants found at toxic waste sites.³³ According to the Agency for Toxic Substances and Disease Registry (ATSDR), between 9% and 34% of drinking water supply sources tested in the U.S. contain some TCE.³⁴

Early exposure, cancer later in life

Recent research shows that early life exposures can increase the risk of cancer many decades later. Laboratory animal studies, for example, show that early exposures increase the susceptibility of the breast and prostate gland to cancer in adulthood.^{35,36} In humans, *in utero* exposure to diethylstilbestrol, a synthetic estrogen, increased the risk of reproductive tract and breast cancer in women decades after birth.³⁷

A 2007 report documented a strong association between higher

early-life exposure to a pesticide called dichlorodiphenyltrichloroethane (DDT) and later development of breast cancer.³⁸ While previous studies that had looked

at the relationship between breast cancer and the levels of DDT in women at the time of breast cancer diagnosis did not find a strong connection,³⁹ the more recent study used stored blood samples to determine the DDT levels the women were exposed to when they were younger. Women who were exposed to higher levels of DDT before age 14 had a markedly increased risk of breast cancer later in life, compared to women whose DDT levels were lower. But higher exposures after the age of 14 were not associated with an increased risk. These and many other studies demonstrate that exposures to hazardous chemicals during vulnerable periods of development can have profound effects that may not manifest until later in life.^{40,41}

These and many other studies demonstrate that exposures to hazardous chemicals during vulnerable periods of development can have profound effects that may not manifest until later in life.

Breast cancer is a leading cause of death in women.⁴² Breast cancer rates in the U.S. increased by more than 40% between 1973 and 1998.⁴³ Today, a woman's lifetime risk of breast cancer is one in eight, up from 1 in 10 in 1973.⁴⁴ The study of DDT exposure

in young women, described above, has been modeled in laboratory animals, where early life exposures to low doses of chemicals have been shown to increase the risk for breast cancer by affecting mammary development and lifetime susceptibility to cancer. For example, in laboratory animals, bisphenol A, dioxin, and perfluorooctanoic acid (PFOA) have been shown to alter gene expression and/or modify mammary gland development, increasing the later risk of cancer.^{45,46,47}

A 2007 literature review identified 216 chemicals associated with increases in mammary gland tumors in at least one well-conducted animal study.⁴⁸ Of these, 73 have been present in consumer products or as contaminants of food, 35 are air pollutants, 29 are produced

Table 1: Commonly Found Chemicals Known or Reasonably Anticipated to Be Human Carcinogens⁵³

| | | |
|----------------------|-----------------------|------------------------|
| Arsenic | Chromium (hexavalent) | Nickel |
| Asbestos | Coal Tars | Silica |
| Benzene | 1,4-dioxane | Styrene |
| Benzidine | Ethylene oxide | Sulfuric Acid |
| Butadiene | Formaldehyde | Toluene Diisocyanate |
| Cadmium | Lead | Trichlorethylene (TCE) |
| Carbon Tetrachloride | Methylene Chloride | Vinyl Chloride |



toxins from our food, water, and air that needlessly increase health care costs, cripple our Nation's productivity, and devastate American lives."⁵⁰

The asbestos example

Effective TSCA reform will give EPA the power to restrict cancer-causing chemicals like asbestos, a material that has been banned in 55 other countries.⁵¹ In 1989, EPA banned asbestos in almost all products, but a federal appellate court overturned the ban on the grounds that the agency failed to meet its burden of proving that asbestos presented an unreasonable risk. The chilling effect of this court decision is clear: EPA hasn't tried to use TSCA to ban or restrict the

production or use of a chemical since.⁵²

To protect public health, EPA needs the proper authority to restrict human carcinogens to which people are exposed. TSCA should require EPA to assess chemicals and hold chemical manufacturers responsible for demonstrating the safety of their products.

at more than 1 million pounds per year in the United States, and 25 have involved occupational exposures to more than 5000 women. Yet, despite the near certainty of widespread human exposure to many of these chemicals, the findings have triggered virtually no regulatory or other policy response.

President's Cancer Panel calls for increased regulation of chemicals

In its 2008-2009 Annual Report, the President's Cancer Panel—appointed by President George W. Bush—summarized its investigation on evidence linking chemicals to various kinds of cancer, and concluded that, despite remaining uncertainties, we know enough to act. According to the Panel, “the true burden of environmentally induced cancer is grossly underestimated.”⁴⁹

Singling out TSCA as an “egregious example of ineffective regulation of environmental contaminants,” the Panel called on President Obama to use the power of his office “to remove the carcinogens and other

Learning and Developmental Disabilities

The number of American children with learning and developmental disabilities has been climbing over the past decade, reaching nearly one in six by 2008.⁵⁴ The increasing prevalence of autism and attention deficit hyperactivity disorder accounts for most of this change.⁵⁵ The National Academy of Sciences estimates that combinations of environmental factors, including exposure to toxic chemicals, along with genetic susceptibility, cause or contribute to at least 25% of learning and developmental disabilities in American children.⁵⁶

Intellectual disability (formerly referred to as mental retardation) affects 2%, or approximately 1.4 million, children in the United States.⁵⁷ As of 2009, 9% of children—roughly 50 million kids—were diagnosed with attention deficit hyperactivity disorder (ADHD).^{58,59} According to the U.S. Centers for Disease Control and Prevention (CDC), an estimated 1 in 88 children in the United States have an autism spectrum disorder.⁶⁰ Between 1997 and 2008, the prevalence of autism increased nearly 300% nationally.⁶¹ In a seminal study of California’s dramatic rise in autism rates, researchers found that about 30% of the rise could not be explained by changes in the age of diagnosis or the inclusion of milder cases.⁶²

These conditions impose tremendous psychological and economic costs on the affected children, their families, and communities. On average, it costs twice as much to educate a child who has a learning or developmental disability as to educate a child who does not.⁶³ According to the CDC, individuals with an autism spectrum disorder have average medical expenditures that exceed those without the disorder by \$4,110–\$6,200 per year.⁶⁴ A 2006 study reported that the economic costs associated with autism in the U.S. are approximately \$35 billion dollars per year.⁶⁵

Ten chemicals suspected of causing developmental neurotoxicity

In spring 2012, scientists from the National Institute of Environmental Health Sciences and the Mount Sinai School of Medicine listed “10 chemicals and mixtures widely distributed in the environment that are already suspected of causing developmental neurotoxicity.” These are:

1. *Lead*: a heavy metal banned from gasoline in the 1970s, found in old paint, lead pipes and sinkers, toys, jewelry, and other items made of vinyl plastic.
2. *Methylmercury*: released into the air from coal-burning power plants; also found in some medical equipment, switches, personal care products, and fluorescent bulbs.
3. *Polychlorinated biphenyls (PCBs)*: used in electrical transformers; banned in the late 1970s but still widely found in lakes, rivers, soil, fish, and people.
4. *Organophosphate pesticides*: pesticides containing phosphorus that work by disrupting the nervous system; used to kill insects on crops and lawns, and in buildings.
5. *Organochlorine pesticides*: pesticides containing chlorine that work by disrupting the nervous system; used to kill insects on crops and lawns, and in buildings; many but not all have been banned in the United States.
6. *Endocrine disruptors*: chemicals that disrupt the hormone system, including phthalates and bisphenol A (both widely used in plastics), PCBs, brominated flame retardants, perfluorinated compounds, dioxins, organochlorine pesticides, among others.
7. *Automotive exhaust*
8. *Polycyclic aromatic hydrocarbons*: air pollutants from fuel combustion in vehicles, coal-fired power plants, heating, and cooking; also found in tobacco smoke.
9. *Brominated flame retardants*: flame retardant chemicals added to furniture, electronics, building materials, bedding, and a wide range of other products.
10. *Perfluorinated compounds*: used in stain-resistant and nonstick products.

Lead, methylmercury, PCBs, some endocrine disruptors, brominated flame retardants, and perfluorinated compounds are among chemicals subject to regulation by the Toxic Substances Control Act.⁹²

The human brain: more susceptible during development

Much of what we know about chemicals that can cause neurological problems comes from studies of adults—often in the workplace—and from animal studies. For example, lead, mercury, and various organic solvents have been identified in the peer-reviewed, scientific literature as causing neurological effects in adults, mostly through occupational exposures (see Table 2).⁶⁶ Many of these chemicals are in common use and are produced in high volumes,⁶⁷ but for many, we have very little knowledge about their neurologic impact in children. A large number of chemicals have never been evaluated for their neurological impacts in children or adults.

In the last few decades, extensive evidence has accumulated showing that neurotoxic chemicals can have a profound effect on the developing brain at levels that were once thought to be safe, and that may have little or no discernible impacts in adults.⁶⁸ Beginning *in utero* and continuing through adolescence, exposures to certain chemicals during particular time windows of vulnerability can disrupt normal developmental processes with profound and often life-long consequences.^{69,70}

Lead, mercury, arsenic, PCBs, certain flame-retardants (PBDEs), and pesticides are among the chemicals for which the special vulnerability of the developing brain has been extensively demonstrated.^{71,72} Our understanding of the developing brain's unique vulnerability suggests that there may be hundreds or even thousands of additional

chemicals that can have an impact. We have no authoritative estimate of the actual number, primarily because relatively few chemicals have been examined for effects in the developing brain of laboratory animals or children.



Toxic flame retardants example

Scientists continue to identify chemicals with enough evidence to raise serious concern over their effects on brain development. A category of flame-retardant chemicals called polybrominated diphenyl ethers (PBDEs) provides a clear illustration of how current chemical laws fail to protect public health.

PBDEs are used in many products, including upholstery, electronics, carpet, building materials, bedding, and mattresses.^{73,74} Despite some regulatory restrictions on PBDEs, these chemicals remain a serious problem because they break down into more toxic forms and are used in many recycled products like carpet padding. In addition, they persist in the environment for a long time, build up in people's bodies and in breast milk, and are often found at higher levels in children than adults.^{75,76}

An extensive body of scientific literature documents the neurode-

velopmental impacts of PBDEs in laboratory animals. In laboratory studies, low doses of some PBDEs cause deficits in learning, memory and hearing, changes in behavior, and delays in sensory-motor development in mice and rats.^{77,78,79,80,81,82,83}

A landmark study published in 2010 provided the first evidence of the adverse effects of these chemicals on human brain development. The study tracked 329 women who gave birth in lower Manhattan hospitals following the terrorist attacks of September 11, 2001. The researchers found an association between levels of PBDE flame retardants in the babies' cord blood and delays in mental and physical development

measured at 1, 2, 3, 4, and 6 years of age.⁸⁴

In 2004 and 2009, the U.S. government reached a voluntary agreement with chemical manufacturers to begin phasing out three commercial mixtures of PBDEs.^{85,86} Since 2002, at least twelve states have banned one or more of these flame retardants due to the mounting evidence of harm to human health.⁸⁷ Some manufacturers have responded by replacing the three PBDE mixtures with different chemicals that they claimed were safer, with no publicly available information to support their claims.

These replacement flame retardants are now showing up in the environment, including in the atmosphere, sediments, and seagull eggs around the Great Lakes, raising concerns that we have simply moved from one dangerous set of chemicals to another, without adequate safety testing.^{88,89} And, to the extent that these new chemicals are also persistent and bioaccumulative, we will be living

Table 2: Some Chemicals Known to be Neurotoxic to Humans^{91*}

| Metals and inorganic compounds | Organic solvents | | Other organic substances | |
|-----------------------------------|-----------------------|-----------------------|---------------------------------|--------------------------------|
| Aluminum compounds | Acetone | Methyl butyl ketone | Acetone cyanohydrin | Methyl chloride |
| Arsenic and arsenic compounds | Benzene | Methyl cellosolve | Acrylamide | Methyl formate |
| Azide compounds | Benzyl alcohol | Methyl ethyl ketone | Acrylonitrile | Methyl iodide |
| Barium compounds | Carbon disulphide | Methylcyclopentane | Allyl chloride | Methyl methacrylate |
| Bismuth compounds | Chloroform | Methylene chloride | Aniline | p-Nitroaniline |
| Carbon monoxide | Chloroprene | Nitrobenzene | 1,2-Benzenedicarbonitrile | Phenol |
| Cyanide compounds | Cumene | 2-Nitropropane | Benzonitrile | p-Phenylenediamine |
| Decaborane | Cyclohexane | 1-Pentanol | Butylatedtriphenyl phosphate | Phenylhydrazine |
| Diborane | Cyclohexanol | Propyl bromide | Caprolactam | Polybrominated biphenyls |
| Ethylmercury | Cyclohexanone | Pyridine | Cyclonite | Polybrominated diphenyl ethers |
| Fluoride compounds | Dibromochloropropane | Styrene | Dibutyl phthalate | Polychlorinated biphenyls |
| Hydrogen sulphide | Dichloroacetic acid | Tetrachloroethane | 3-(Dimethylamino)propanenitrile | Propylene oxide |
| Lead and lead compounds | 1,3-Dichloropropene | Tetrachloroethylene | Diethylene glycol diacrylate | TCDD |
| Lithium compounds | Diethylene glycol | Toluene | Dimethyl sulphate | Tributyl phosphate |
| Manganese and manganese compounds | N,N-Dimethylformamide | 1,1,1-Trichloroethane | Dimethylhydrazine | 2,2,2-Trichlorotriethylamine |
| Mercury and mercuric compounds | 2-Ethoxyethyl acetate | Trichloroethylene | Dinitrobenzene | Trimethyl phosphate |
| Methylmercury | Ethyl acetate | Vinyl chloride | Dinitrotoluene | Tri-o-tolyl phosphate |
| Nickel carbonyl | Ethylene dibromide | Xylene | Ethylbis(2-chloroethyl)amine | Triphenyl phosphate |
| Pentaborane | Ethylene glycol | | Ethylene | |
| Phosphine | n-Hexane | | Ethylene oxide | |
| Phosphorus | Isobutyronitrile | | Fluoroacetamide | |
| Selenium compounds | Isophorone | | Fluoroacetic acid | |
| Tellurium compounds | Isopropyl alcohol | | Hexachlorophene | |
| Thallium compounds | Isopropyl acetone | | Hydrazine | |
| Tin compounds | Methanol | | Hydroquinone | |

* It is important to note that the listed chemicals are industrial chemicals. Table 2 does not include neurotoxic pesticides, which are regulated under a different federal statute.

with their toxic consequences for years to come.

How chemical policy reform can help

There is solid and mounting scientific evidence on a limited number of chemicals, including those described above, to show that they are harmful to brain development.

Where the weight of the evidence warrants concern, TSCA reform should include swift action to replace known toxic chemicals with safer alternatives.

However, for most of the thousands of chemicals on the market, we have virtually no information about their effects on the developing nervous system. Of the 3,000 chemicals produced in highest vol-

ume (over one million pounds per year), few have been adequately tested for toxicity to the developing brain.⁹⁰ To ensure healthy brain development for future generations, TSCA must be updated to require that all existing and new chemicals are evaluated for their safety for pregnant women, children, workers, and other vulnerable populations.

Alzheimer's and Parkinson's Diseases

An estimated 5.4 million people in the United States have Alzheimer's disease.⁹³ Two-thirds of those with the disease are women.⁹⁴ By 2050, researchers estimate that the number of people with the disease will nearly triple to 16 million.⁹⁵ Of Americans aged 65 and over, 1 in 8 has Alzheimer's disease, and nearly half of people aged 85 and older have the disease.⁹⁶ Deaths from Alzheimer's disease increased 66% between 2000 and 2008.⁹⁷

Parkinson's disease affects approximately 500,000 Americans, with about 50,000 new cases annually.⁹⁸ The prevalence of the disease is expected to double by 2030.⁹⁹ Lack of Parkinson's disease registries, however, make it difficult to estimate the true incidence and trends over time.¹⁰⁰

The Alzheimer's Association estimates that national direct and indirect annual costs of caring for individuals with Alzheimer's disease are \$183 billion.¹⁰¹ Estimates of the costs of Parkinson's disease range from \$13 billion to \$28.5 billion per year.¹⁰²

The link to chemical exposure

The risk of cognitive decline, dementia, and Parkinson's disease increases with age, and most cases are likely to arise from multiple contributing factors. In recent years, the extent to which exposures to environmental chemicals and contaminants throughout the lifespan may play a role has received increased attention.

In one study, 21% of more than a thousand patients with cognitive disorders had medical histories



that suggested they may have been exposed to chemicals either in their workplace or from some other environmental source. Clinicians found that a history of toxic exposure was associated with cognitive decline at significantly younger ages.¹⁰³ Unfortunately, few of the more than 100 industrial chemicals that are known to be toxic to the nervous system generally have been studied for specific impacts on the adult brain, but those few are illustrative.¹⁰⁴

Pesticides

In the 1980s, case reports of individuals who developed Parkinson-like symptoms after injecting a synthetic drug contaminated with 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) sparked interest in looking for environmental chemicals that might have similar effects.¹⁰⁵ Early studies focused on chemicals with structural similarities to MPTP or its breakdown products, including the pesticide rotenone and the herbicide paraquat. Extensive laboratory and epidemiologic

evidence now shows that exposure to certain kinds of pesticides increases the risk of Parkinson's disease.^{106,107} Although less well studied, pesticide exposures may also increase the risk of cognitive decline and dementia.^{108,109}

Solvents

Solvents are another class of chemicals that appear to increase the risk of Parkinson's disease in exposed workers. Solvents are used for cleaning, degreasing, extraction, surface coating, and laboratory work. They are components of paints, inks, glues, adhesives, and hydrocarbon fuels. Occupational exposure to solvents such as carbon disulfide, methanol, n-hexane, and trichloroethylene (TCE) is associated with an increased risk of Parkinson's disease.^{110,111,112} TCE is a particular concern. Not only is it frequently used as a degreasing agent in industry, but it is also a common surface and groundwater contaminant, resulting in widespread, low-level exposures in the general population.¹¹³

Lead and other metals

Lead, which is notorious for its impacts on the developing brains of children, also now appears likely to increase the risk of neurodegenerative disorders in people as they age.

A study of older men in the general population found that increasing levels of lead in their bones was associated with accelerated cognitive decline. The group with the highest lead levels had 15 years of additional cognitive aging compared to the group with the lowest levels when they were re-tested several years later.¹¹⁴ Similar findings are also reported in women.¹¹⁵

Elevated bone lead levels are also associated with an increased risk of Parkinson's disease.¹¹⁶

Studies in rodents designed to examine mechanisms by which early-life lead exposure might contribute to late-life neurodegeneration show that prenatal lead exposures modify the expression of certain genes later in life, resulting in increased production of Alzheimer-associated abnormal brain proteins.¹¹⁷ The same delayed, late-life increase in Alzheimer's disease-related proteins was reported in aged monkeys exposed in infancy to low levels of lead.¹¹⁸

New animal studies also have resurrected the 1960s controversy about the role of aluminum in neurodegenerative disease. One small

study showed that when rodents were chronically exposed to dietary aluminum (similar to typical human exposure levels), aluminum accumulated in the brain.¹¹⁹ A larger follow-up study in rats showed that the more aluminum a rat received in its diet, the more memory loss the rat exhibited.¹²⁰

Excessive inhalation of manganese-containing fumes also can increase the risk of Parkinson-like symptoms.¹²¹

Polychlorinated biphenyls (PCBs)

Before they were effectively banned under TSCA in the late 1970s, polychlorinated biphenyls (PCBs) were used for many years as flame retardants, plasticizers in paints,



lubricants and coolants in electrical equipment, and adhesives.^{122,123} As a result of their widespread use, many people and wildlife throughout the world have been exposed.¹²⁴

More than 30 years after they were effectively banned, PCBs continue to contaminate the environment because they are persistent, or not easily broken down, and move readily from land to air and water. They also bioaccumulate and continue to enter and contaminate the food supply, which is an ongoing source of human exposure.¹²⁵

Biomonitoring data from the CDC show that the American public is still widely contaminated with PCBs.¹²⁶ Although the levels of PCBs in the general population are decreasing, certain subpopulations remain highly exposed, especially those regularly consuming contaminated fish.¹²⁷

In the years following TSCA's passage, we learned that, like most chemicals, PCBs can cross the placenta, directly exposing the fetus.¹²⁸ Numerous studies show that prenatal exposure to PCBs interferes with normal brain development.^{129,130,131} More recently, we have learned that PCBs may increase the risk of both Alzheimer's disease and Parkinson's disease.

Three published epidemiologic studies have explored the effects of PCBs on cognitive decline or dementia, and each found that higher levels of exposure are associated with an increased risk of dementia or cognitive impairment. While PCB exposures were relatively high in two of the studies,^{132,133} exposures in the third were closer to those in the general population.¹³⁴

A retrospective mortality study of more than 17,000 workers occupationally exposed to PCBs reported a nearly threefold excess of Parkinson's disease-

related deaths and twice as many dementia-related deaths in women most highly exposed to PCBs.¹³⁵ Another postmortem study found higher levels of PCBs in the brains of people with Parkinson's disease than in control subjects.¹³⁶ Animal and cellular studies also have shown that some PCBs produce Parkinson-like changes in the brain or brain cells.¹³⁷

Thus, PCBs tell a cautionary tale: introduction of persistent, bioaccumulative, and toxic chemicals into commerce will predictably have adverse health and economic consequences for many years, even after they are banned.

How chemical policy reform can help

To be effective, TSCA reform must recognize the unique dangers posed by exposure to persistent, bioaccumulative, and toxic pollutants (PBTs), such as PCBs, PBDEs, and heavy metals, and include provisions to ban them except for critical uses. Communities and populations that bear disproportionately high burdens of PBT contamination must be the focus of exposure reduction efforts.

In addition, it is now clear that environmental chemicals can contribute to neurodegenerative changes in the adult and aging brain. Thus, in order to protect public health, TSCA reform also must include provisions for assessing the effects of industrial chemicals on the brain throughout the lifespan.

Reproductive Health and Fertility Problems

In the U.S. today, there is increasing concern that environmental contaminants may be harming the reproductive health and fertility of women and men. Reproductive and fertility problems appear to be on the rise.

In women:

- At least 12% of women reported difficulty in conceiving and maintaining pregnancy in 2002, an increase of 40% from 1982.^{138,139} From 1982 to 1995, the prevalence of infertility almost doubled in younger women, ages 18–25.^{140,141} A recent update concludes that the trend may have leveled off, although there is disagreement on this.^{142,143}
- Fibroids and other fertility-related diseases, like endometriosis and polycystic ovarian syndrome, are diagnosed more frequently now, which may be the result of a true increase, better detection, or both.¹⁴⁴

In men:

- According to a large study of men from the Boston area, testosterone levels in adult men are declining. This decline is not explained by an increase in age or other health or lifestyle factors such as obesity or smoking.¹⁴⁵
- Testicular cancer increased by 60% between 1973 and 2003 in the U.S.¹⁴⁶

- Sperm counts have declined in men in some areas of the U.S., Europe, and Australia.¹⁴⁷

(deformity of the penis) has increased, whereas in others, increases have leveled off.^{152,153}



Testicular dysgenesis syndrome (described below), resulting from *in utero* exposure to endocrine-disrupting chemicals, has been proposed as an integrating explanation for the observed increases in testicular cancer, congenital abnormalities of the male reproductive tract, and decreases in sperm count.¹⁵⁴ Indeed, a growing and compelling body of evidence suggests that chemical exposures are likely to be influencing many of these trends in females and males.^{155,156,157}

The financial consequences of these conditions are highly significant.

In 2002, U.S. patients and their insurers spent an estimated \$2.9 billion on infertility treatments alone.¹⁵⁸

The link to chemical exposure

The CDC has published data showing that exposures to endocrine-disrupting chemicals like phthalates, bisphenol A (BPA), perfluorinated compounds, and cadmium are common. The CDC reports that almost everyone has these chemicals in their bodies, some at levels near or above those shown in scientific studies to cause adverse effects on reproductive health.^{159,160,161}

Recent investigations show that higher levels of exposure to

In children:

- In U.S. girls, puberty is beginning earlier than in the past.¹⁴⁸ A weight-of-the-evidence evaluation of human and animal studies suggests that endocrine-disrupting chemicals, particularly estrogen mimics and anti-androgens, as well as increased body fat and certain social circumstances, can advance the onset of puberty.^{149,150}
- Reproductive tract abnormalities are increasing in certain populations. In one analysis of two U.S. surveillance systems, cryptorchidism (undescended testicle(s)) increased 200% between 1970 and 1993.¹⁵¹ In some surveillance systems, the incidence of hypospadias

endocrine-disrupting chemicals are associated with adverse effects on reproductive measures and birth outcomes in the general population, including reduced sperm quality in men, premature birth, low birth weight, and behavioral changes in children.^{162,163,164,165,166,167} These findings are consistent with a large body of experimental laboratory data.

The examples below illustrate the reason for concern about exposure to some chemicals and the potential impacts on reproductive health. Unfortunately, there are far more chemicals about which we have little or no data on the potential for negative impacts.

Bisphenol A

Over the past decade, a wealth of new studies has shown that some chemicals can act as endocrine disruptors—chemicals that interfere with normal hormone function and regulation. Among these are animal studies that link prenatal and early-life exposures to BPA, which is found in polycarbonate plastic and some food and beverage can linings, to permanent reproductive changes and increased risks of later reproductive health problems, such as infertility and early puberty.^{168,169}

Animal studies also show that prenatal exposures to BPA at levels similar to those experienced by people in the general population alter the development of the prostate and mammary glands, increasing the susceptibility for developing cancer later in life.^{170,171}

In laboratory animals, including non-human

primates, BPA previously was shown to affect the development of the brain, causing changes in gender specific behaviors.¹⁷² Recently, a human study reported that the higher a pregnant woman's BPA levels were during her first 16 weeks of pregnancy, the more likely her child was to later show behavior somewhat atypical of its gender at age two. Girls engaged in more masculinized behaviors, while boys were more feminized.¹⁷³

Phthalates

Prenatal exposure to phthalates commonly found in personal care products, as a food contaminant, and in items made from PVC plastic, or vinyl, has been linked to altered development of the male reproductive system and feminized behaviors in boys. Some researchers now group the male birth defects—undescended testicle(s) and deformity of the penis—with two other conditions of the male reproductive tract—low sperm counts and testicular cancer. These four medical conditions are collectively called testicular dysgenesis

A wide range of wildlife populations has been adversely affected by exposure to endocrine-disrupting contaminants. Impacts among birds, fish, shellfish, mammals, and reptiles include decreased fertility and increased reproductive tract abnormalities, feminization and demasculinization in the males, and masculinization and defeminization in the females.¹⁷⁴

syndrome (TDS). Animal studies suggest that a TDS-like condition can be observed after fetal exposure to phthalates.¹⁷⁵

In November 2009, a study of mothers and their children found that boys born to mothers with higher levels of phthalates in their urine during pregnancy were more likely to exhibit feminized behaviors than boys whose mothers had lower levels of exposure.¹⁷⁶

Perfluorinated chemicals

Studies of perfluorinated chemicals, commonly used in stain-proof and non-stick products, also may negatively affect reproductive health. Some studies have found that higher levels of maternal exposure to these compounds are tied to lower birth weight in newborns.^{177,178,179,180} Another study found that Danish men with higher levels of perfluorinated compounds had fewer normal sperm and lower sperm concentrations.¹⁸¹ A recent study of children living near a perfluorinated chemical produc-





tion plant found both boys and girls had delayed puberty.¹⁸² These findings are particularly concerning, since exposure to perfluorinated chemicals is nearly ubiquitous in the general population, including in women who are pregnant.^{183,184}

Cadmium

Cadmium, a metal used in batteries, pigments, metal coatings, and plastics, is a known testicular toxicant and is linked to gynecological disorders such as endometriosis.¹⁸⁵ It also has been found to have hormonal properties.¹⁸⁶

How chemical policy reform can help

In June 2009, The Endocrine Society, a professional association devoted to research on hormones and the clinical practice of endocrinology, issued a scientific

statement on endocrine-disrupting chemicals, which stated:¹⁸⁷

The evidence for adverse reproductive outcomes (infertility, cancers, malformations) from exposure to endocrine disrupting chemicals is strong, and there is mounting evidence for effects on other endocrine systems, including thyroid, neuroendocrine, obesity and metabolism, and insulin and glucose homeostasis.

Among the statement's recommendations for the future is this suggestion:

As endocrinologists, we suggest that The Endocrine Society actively engages in lobbying for regulation seeking to decrease human exposure to the many endocrine-disrupting agents.

In November 2009, the American Medical Association (AMA) passed a resolution introduced by The

Endocrine Society that calls for the AMA to work with the federal government to enact new federal policies to decrease the public's exposure to endocrine-disrupting chemicals.¹⁸⁸

These "new federal policies" would come through effective reform of TSCA. Authoritative bodies have listed more than 50 industrial chemicals as causing reproductive toxicity.¹⁸⁹ TSCA reform should prioritize action on these and other chemicals—including bisphenol A, phthalates, and perfluorinated chemicals—which have been identified as harmful to reproduction and development. TSCA reform also should require evaluation of the effect of chemicals on reproduction and child development before they are introduced into the market and as a condition for remaining on the market.

Asthma

The number of people in the United States with asthma roughly doubled from 1980 to 1995 and continues to rise.¹⁹⁰ Between 2001 and 2009, asthma prevalence increased 12.3% from 20.3 million to 24.6 million Americans. By 2009, nearly 1 in 12 people suffered from the disease.¹⁹¹

Asthma is one of the most common childhood chronic diseases, and a higher percentage of children than adults have asthma. Nearly one in ten (9.6%, or about seven million) children in the U.S. have asthma. Diagnoses are especially high among boys. The greatest rise in asthma rates from 2001 to 2009 was among black children, with a nearly 50% increase in prevalence. Seventeen percent of non-Hispanic black children had asthma in 2009, the highest rate among racial/ethnic groups.¹⁹²

The annual costs associated with asthma grew from about \$53 billion in 2002 to about \$56 billion in 2007, an increase of 5.7%. These costs include medical expenses (\$50.1 billion per year), loss of productivity resulting from missed school or work days (\$3.8 billion per year), and premature death (\$2.1 billion per year).¹⁹³

The link to chemical exposure

The doubling of asthma rates over the last two decades has prompted researchers to examine the role that various environmental factors may play in this trend. Genetics alone cannot explain such dramatic increases

in prevalence over such a short time.

Asthma is highly likely to result from the interaction of a complex mixture of underlying risk factors. Maternal nutrition, exposures to environmental contaminants, and stress can alter fetal lung and immune system development, not only prenatally but also after birth during infancy and childhood. Post-natal exposures to allergens and indoor and outdoor air pollution also can increase asthma risk.^{194,195} One theory holds that altered bacterial composition in the intestine and living in environments that are “too clean” can increase risk as well.

But whatever the explanations of this troubling trend, extensive evidence from occupational and general population epidemiological

studies and medical case reports documents that hundreds of chemicals can cause asthma in individuals previously free of the disease or can put asthma patients at greater risk for subsequent attacks.^{196,197}

A 2007 literature review found 21 studies linking indoor residential chemical emissions with respiratory health or allergy problems in infants or children.¹⁹⁸ The study identified formaldehyde (in particleboard), phthalates (in plastic materials), and recent interior painting as the most frequent risk factors. Elevated risks also were reported for renovation, cleaning activities, new furniture, carpets, and textile wallpaper. Table 3 provides an overview of the indoor sources identified in this study.

A 2004 Swedish study compared 198 young children with asthma and allergies to 202 healthy control subjects. The home environment of every child was examined, with air and dust samples taken in the room where the child slept. The children whose bedrooms contained higher levels of the phthalate DEHP were more likely to have been diagnosed with asthma by a physician.¹⁹⁹ Current studies are reexamining the possible association between phthalates and asthma with more rigorous prospective study designs.

How chemical policy reform can help

Consumers, retailers, and other downstream users of chemicals—including manufacturers and distributors of toys and other products—have a problem in common: they cannot gain access to basic information about the chemicals used to make their products. Because federal law does not ensure the right to know



Table 3: Examples of Chemical Pollutants from Indoor Sources Implicated in Asthma or Its Symptoms²⁰⁰

| <i>Compounds</i> | <i>Example Sources</i> |
|--|--|
| Aldehydes | |
| Formaldehyde | Composite wood and other products with urea-formaldehyde resin, some architectural finishes, tobacco smoke, and other combustion processes |
| Aromatics | |
| Benzene, toluene, xylenes, styrene, ethylbenzene, ethyltoluenes, and naphthalene | Motor vehicle exhaust, gasoline/fuel, tobacco smoke, solvent-based paints, floor adhesives, PVC flooring, carpeting, printed material, solvent-based consumer products |
| Dichlorobenzene | Moth balls, bathroom deodorizers |
| Chlorobenzene | Possibly solvent-based paints |
| Aliphatic hydrocarbons | |
| Hexane, nonane, decane, undecane, and dodecane | Some architectural finishes, floor adhesives, PVC flooring, waxes, aerosol air fresheners |
| Aliphatics (general) | Carpet padding, adhesives, caulks, paint |
| Volatile organic compounds (VOCs), other | |
| Methylcyclopentane | Motor vehicle exhaust and evaporative emissions |
| Butanol | Some architectural finishes |
| Limonene | Cleaning products, air fresheners, many consumer products |
| Tetrachloroethylene | Dry-cleaning solvent and dry-cleaned clothing |
| Trichloroethylene | Aerosol paints, adhesives, lubricating oils, paint removers |
| Phthalate esters | |
| BBZP | Vinyl flooring, carpet tile, adhesives |
| DEHP | Vinyl flooring, PVC plastics |

what we are exposed to, we don't have the information we need to identify all the sources of indoor air pollution that may be causing asthma or triggering symptoms.

How can an expectant mother determine if there is formaldehyde in the particleboard used to make

cribs and other nursery furnishings? How does a new father decide which baby shampoo may contain phthalates? Why should new parents have to worry about whether potentially dangerous chemicals are in the products they choose for their newborn children?

To be effective, TSCA reform should include a requirement that chemical manufacturers publicly disclose information on the uses of and health hazards associated with their chemicals, and the ways that people could be exposed in their homes, schools, or places of work.

Reducing Our Health Care Costs



“If our students are getting sick because we’ve built schools in polluted areas, they are going to fall behind. The poor who get sick because of toxins in their neighborhoods are the same people who typically seek treatment in emergency rooms. That drives up health care costs for everyone. And environmental health issues hold back economic growth. Let me repeat that, because there are a lot of people who think that we can’t address these issues and strengthen our economy. In fact, we must address these issues to strengthen our economy. Environmental health issues hold back economic growth.”

EPA Administrator Lisa Jackson at the American Public Health Association, November 8, 2009²⁰¹

EPA Administrator Jackson offered a commonsense equation in her speech to the American Public Health Association: a decline in exposure to toxic chemicals will result in a decline in chronic disease and lower health care costs.

While it is difficult to quantify how much money would be saved under TSCA reform, some sense of the potential savings and economic gains can be gleaned from sources that have used sophisticated modeling to project costs and savings.

Health and social costs of hazardous environmental exposures in children

Researchers estimated that the annual cost of environmentally-attributed diseases in American children was \$76.6 billion per year, or 3.5% of U.S. health care costs, in 2008.²⁰² This is a conservative estimate, as it only looked at pediatric lead poisoning, asthma, childhood cancer, prenatal methylmercury exposure, intellectual disability, autism, and attention deficit hyperactivity disorder.

In addition to estimating the significant costs attributed to environmental exposures in children, the analysis illustrates the financial benefits that can be traced to policy initiatives that led to reductions in childhood lead exposure over the past decade. After Congress passed laws requiring the removal of lead from gasoline, paint, food containers, children’s toys, and municipal drinking water systems, there was an 80% decline from the 1970s to the 1990s in human exposure to the heavy metal. Likely because of the decreased lead exposures, the researchers identified a 10% decrease in the annual costs associated with childhood lead exposure, as compared to a previous analysis at the end of the 1990s.²⁰³

Moreover, the improvement in cognitive ability associated with decreased lead exposure is predicted to result in increased worker productivity, with an estimated economic benefit to the U.S. of between \$110 and \$319 billion dollars each year.²⁰⁴

Removing lead from gasoline, paint, and other sources continues to be one of the most successful efforts

to prevent disease and disability in the U.S. The numbers not only show that regulation of lead was directly linked to a drop in blood lead levels, but the legislative action saved significant health care costs and will result in economic gain due to increased worker productivity.

What would happen if we did something similar with the other known hazardous chemicals in the marketplace? What kind of money could the United States save by preventing exposures to known harmful chemicals like formaldehyde, TCE, and hexavalent chromium?

We have a significant opportunity to save Americans money and eliminate suffering associated with chronic disease and illness. Reforming federal law could dramatically reduce American’s exposure to harmful chemicals, as well as the skyrocketing health care costs in this country.

Conclusion

When the Toxic Substances Control Act became law in 1976, smoking was permitted in airplanes, hospitals, and all other public places. There were no laws requiring that children or adults wear seat belts. Lead was still being added to gasoline. In the last few decades, Americans and their elected officials have taken action on all of these issues and witnessed significant improvements in public health.

The last 30 years of environmental health studies make clear that TSCA reform presents another opportunity to dramatically improve public health:

- *Cancer.* Recent research on the timing of chemical exposures and later development of breast cancer demonstrates why EPA needs the authority to restrict human carcinogens and other toxic chemicals to which people are exposed. TSCA reform should require that chemical manufacturers demonstrate the safety of their products.
- *Learning and developmental disabilities.* New studies demonstrating the ability of small amounts of chemicals to permanently harm the developing brain illustrate the critical need to reduce or eliminate toxic chemical exposures, especially during particular time windows of vulnerability. TSCA reform should ensure that all existing and new chemicals are safe for pregnant women, children, workers, and other vulnerable populations.
- *Alzheimer's and Parkinson's diseases.* Research suggesting linkages between chemical exposures and neurodegenerative diseases highlights the unique dangers posed by exposure to persistent, bioaccumulative, and

toxic chemicals (PBTs). TSCA reform should provide for the phase out of PBTs, except for critical uses. Communities and populations that bear disproportionately high burdens of legacy contamination should be the focus of exposure reduction efforts.

chemicals, and the ways that people could be exposed in their homes, schools, or places of work.

We know that chronic diseases are the result of multiple, interacting risk factors. Studies increasingly show that exposures to environ-



- *Reproductive health and fertility problems.* Findings on reproductive health and fertility problems make the case for prioritized regulatory action on bisphenol A, phthalates, perfluorinated compounds, and other endocrine-disrupting chemicals that new science identifies as harmful to reproduction and development.
- *Asthma.* The growing body of research linking asthma to chemical exposures demonstrates why TSCA reform should require chemical manufacturers to publicly disclose information on the uses of and health hazards associated with their

mental chemicals are among them. The interplay of variables begins before conception and continues for an entire lifetime. While we have undertaken public health measures to address many of the risk factors that lead to common diseases, we are constrained by an antiquated statute—unchanged for more than thirty-five years—that interferes with our capacity to reduce exposures to harmful chemicals and to learn about the hazards of chemicals before fetuses, infants, children, and adults of all ages are exposed to them. This must change.

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The Safer Chemicals, Healthy Families coalition includes nurses, parents, advocates for the learning and developmentally disabled, scientists, environmental health advocates, and concerned citizens from across the nation. These diverse groups are united by their common concern about toxic chemicals in our homes, places of work, and products we use every day.



Safer Chemicals
Healthy Families

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