



Global Indoor Health Network (GIHN)

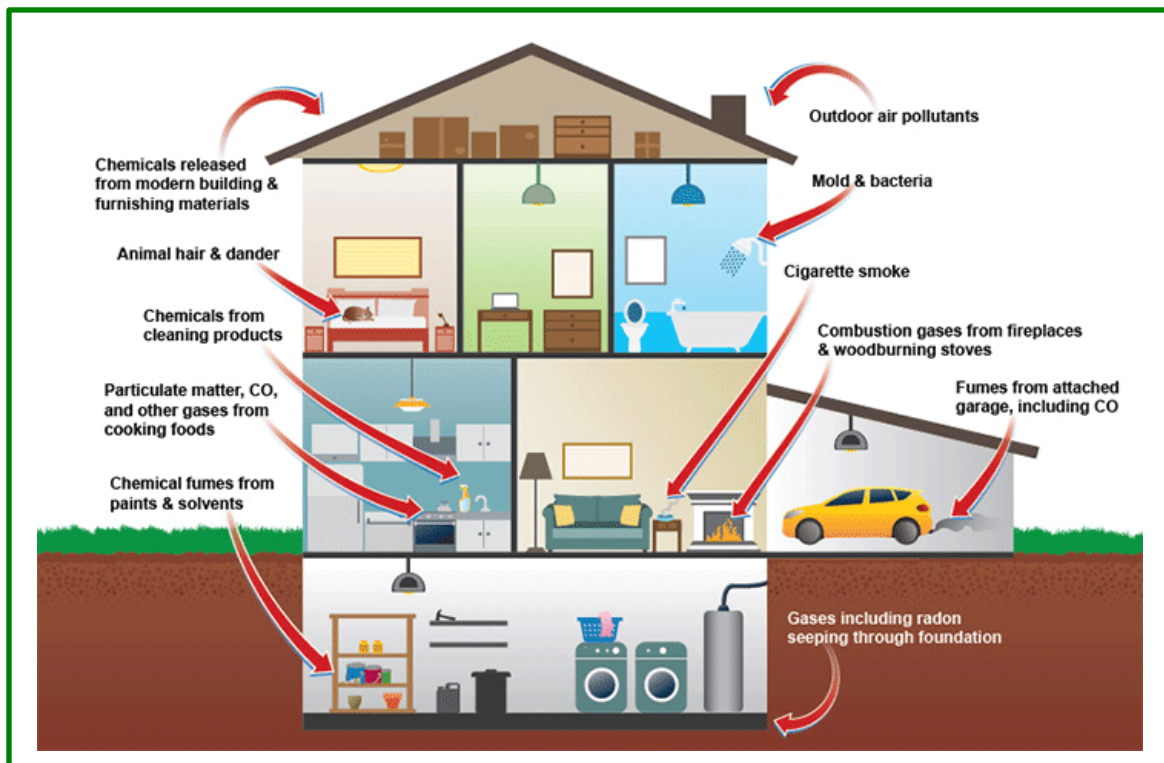
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Indoor Air Contaminants

(excludes molds, mycotoxins and related contaminants in water-damaged buildings)



There are many different types of indoor air pollutants. This diagram represents only a few.

To learn more about contaminants in water-damaged buildings, read our paper titled “Molds, Mycotoxins and Related Contaminants in Water-Damaged Buildings.”

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Overview

Astute physicians and healers have been aware of the existence of environmental toxins for over a thousand years. The list of substances, both naturally occurring and manmade, which may cause harm to the human organism, is continually growing. Curiously, while heart disease, cancers and rare exotic illnesses frequently grab headlines, illness due to environmental sources, though incredibly common, often receive little or no media coverage.

Typically, little education is offered to allopathic physicians in their medical training on this subject. Hence, there is poor understanding of the concept that our environment is capable of slowly poisoning its inhabitants.

In this paper, we will discuss several common indoor air pollutants (excluding molds, mycotoxins, bacteria and biological contaminants found in water-damaged buildings). To learn more about those indoor air contaminants, read our paper titled “Molds, Mycotoxins and Related Contaminants in Water-Damaged Buildings.”

Because there are so many contaminants that effect indoor air quality, our discussion is not mean to be all inclusive. We have provided a brief overview of several common indoor air contaminants and included references to many research papers. However, there are thousands of additional research papers available.

The significant impact of indoor air pollution is summed up in the following reports:

In a 1989 report from the U.S. Environmental Protection Agency (EPA):

Health effects from indoor air pollution cover the range of acute and chronic effects, and include eye, nose, and throat irritation, respiratory effects, neurotoxicity, kidney and liver effects, heart functions, allergic and infectious diseases, developmental effects, mutagenicity, and carcinogenicity.¹

In a 2010 report by the WHO on indoor air quality and selected pollutants:

Indoor exposure to air pollutants causes very significant damage to health globally—especially in developing countries.²

Indoor exposure to air pollutants causes very significant damage to health globally. Health effects from indoor air pollution cover the range of acute and chronic effects, and include eye, nose, and throat irritation, respiratory effects, neurotoxicity, kidney and liver effects, heart functions, allergic and infectious diseases, developmental effects, mutagenicity, and carcinogenicity.

In a 2016 report by UNICEF that focuses on the impact on children:

In this 2016 report, UNICEF considers the combined impact of outdoor and indoor pollutants on children. Clearly, outdoor pollution also affects our indoor environments. UNICEF emphasizes the urgent need for countries to take action now. They say it very succinctly with the statement---“the impact is commensurately shocking.”³

Brief history of indoor environmental exposures

The published roots of toxicology extend back over a millennium.⁴ However, thorough understanding of many toxins is not nearly as prevalent as one would expect in our modern medical society.

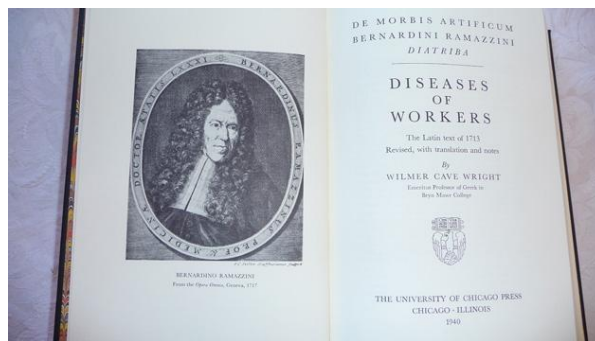
Typically, a few individuals discover the toxic potential of a substance (such as asbestos) and publish their findings. However, history has shown that it may take 3-4 decades or longer for the public and Western medicine to accept (or uncover) the truth about the danger.

Occasionally, an environmental illness becomes national news overnight. Legionnaire’s disease, caused by the *Legionella* bacteria, became a media superstar in the summer of 1976 as hundreds of people became ill at the American Legion convention in Philadelphia, Pennsylvania. However, this is the exception for most environmental poisons.

If we look at tobacco as an example, it was more than 50 years before the truth was revealed and, yet, the tobacco companies are still continuing to produce and sell those products.

This delay in widespread awareness of scientific findings is not new and was certainly around in the times of Copernicus (1473-1543), Galileo (1564-1642) and others whose theories and proofs were opposed by powerful controlling bodies. In time, however, the truths of their works prevailed.

Another important environmental health publication in history was a book by Bernardini Ramazzini in 1700. He published a book titled “De Morbis Artificum” (Diseases of Workers) that discussed the health hazards affecting workers including chemicals, dust, metals and other agents.⁵



This book highlights a number of environmental toxins, most of which have already been accepted as capable of causing significant disease. Studying their individual histories of usage and poison potential discoveries confirms that we, as people and as physicians, are usually slow to accept that these substances—found in most homes, schools and workplaces—are capable of harming us and our children.

A 2013 research paper describes the situation as follows:

Escalating numbers of people throughout the world are presenting to primary care physicians, allergists, and immunologists with myriad clinical symptoms after low-level exposure to assorted everyday chemicals such as smoke, perfumes, air fresheners, paints, glues and other products.⁶

The emerging problem of ubiquitous adverse toxicant exposures in modern society has resulted in escalating numbers of individuals developing a chemical sensitivity (CS) disorder. As usual in medical history, iconoclastic ideas and emerging evidence regarding novel disease mechanisms, such as the pathogenesis of CS, have been met with controversy, resistance and sluggish knowledge translation.⁶

As usual in medical history, iconoclastic ideas and emerging evidence regarding novel disease mechanisms have been met with controversy, resistance and sluggish knowledge translation.

To learn more about the decades-old strategy of denying the health effects of environmental exposures, read our paper titled “Discussion of Naysayers and Deniers.” It provides a detailed discussion of Big Business and other naysayers and their long-term strategy to deny the health effects of tobacco, mold and other toxins.

Brief summary of the financial impact

The U.S. EPA estimates that up to 50% of all U.S. buildings are water damaged, and the bill to correct all these spaces is enormous. State and Federal governments do not want to pay this price, nor do school districts or other employers. Building insurers have quietly exempted themselves via the addition of mold riders in their policies (non-existent 20 years ago).



On a global basis, “the prevalence of indoor dampness varies widely within and among countries, continents and climate zones. It is estimated to affect 10–50% of indoor environments in Australia, Europe, India, Japan and North America. In certain settings, such as river valleys and coastal areas, the conditions of dampness are substantially more severe than the national average.”⁷

Meanwhile, more and more people are getting sick in the buildings where they live, attend school and work. By keeping the issue hushed, government agencies and Big Business have avoided payment and have pushed the costs onto the “little guy” (i.e., the individual homeowners, small businesses, etc.).

Although the risks of mold are still being denied or downplayed by naysayers and government agencies, there is increasing attention toward other types of indoor air pollution. One area of interest is endocrine-disrupting chemicals. In a 2016 report, they estimated the cost of

healthcare and lost earnings due to illness caused by endocrine-disrupting chemicals at \$340 billion in the U.S. They also provided an estimate of these same costs for Europe, showing an annual cost of \$217 billion.⁸

A 2017 report from Europe reported the annual cost of asthma and chronic obstructive pulmonary disease at €82 billion (\$93 billion).⁹

In Finland, the estimated the cost of health problems associated with mould and damp is 450 million euros each year. If you add the cost of repairing the problems, the total reaches 1.4 billion euros.¹⁰

A 2011 report estimated the cost of environmental disease in children at \$76.6 billion. It is important to note that this estimate includes only the costs of lead poisoning, prenatal methylmercury exposure, childhood cancer, asthma, intellectual disability, autism, and attention deficit hyperactivity disorder. The actual costs would be much greater if all types of environmental exposures were included. The authors stated that a new estimate was needed because “few important changes in federal policy have been implemented to prevent exposures to toxic chemicals.”¹¹

According to a 2016 report, the estimated cost in Africa of outdoor pollution is \$215 billion and indoor pollution is \$232 billion.^{12,13}

The estimated cost of indoor and outdoor pollution in the European Region is \$1.6 trillion. This is nearly 1/10 of the gross domestic product (GDP) of the entire European Union.

Another study estimated the cost of air pollution (indoor and outdoor pollution) of 53 countries in the European Region at \$1.6 trillion. This is nearly 1/10 of the gross domestic product (GDP) of the entire European Union.¹⁴

If you look at the other side of the equation, billions of dollars could be saved if we implemented specific steps aimed at improving indoor air quality.

According to a 2000 report by Fisk, et al “the estimated potential annual economic savings plus productivity gains, in 1996 dollars, are approximately \$40 to \$200 billion” if we would implement specific scenarios to improve indoor environmental quality in U.S. office buildings.¹⁵

Imagine how big those savings would be if we also made these changes in schools, homes and other structures around the world.

Individuals, employees, teachers, students, families and potentially millions of people are suffering, while Big Business works hard to protect their financial interests.

For details about the statistics and financial impact of indoor air contaminants, read our paper titled “Global Burden of Indoor Air Contaminants.”

Indoor air contaminants cause significant damage to health globally.

It is staggering to comprehend the enormous impact on our global society as literally millions of individuals and families are harmed by contaminants inside our homes, schools and workplaces. The financial costs are equally staggering with estimates in the hundreds of billions of dollars. The statistics presented throughout this paper should catch the attention of every physician, every lawmaker and every layperson.

Changes over the years in building philosophy, construction materials, pesticides, usage patterns, etc., along with new awareness and improved testing capabilities, have brought us to the understanding that some buildings are sick and can make their occupants sick. Shoddy construction practices and environmental disasters also contribute.

People spend approximately 90% of their time indoors. As such, it is a disconcerting thought that the structures where we live, work and go to school might lead to significant and even deadly health problems.

As a society, we trust and even cherish many of these edifices. Yet some harbor hidden and harmful dangers.

Imagine how different things could be if the truth came to light and all vested parties worked together to improve our indoor air.

- Medical costs would drop significantly.
- Doctors would have accurate, reliable information and be able to provide proper medical diagnosis and treatment.
- We could reverse the huge increase in asthma rates and reduce the billions of dollars being spent on asthma-related illnesses.
- Builders and construction firms would have the information they need to create safe and healthy homes, schools and workplaces.
- Teachers and students could teach and learn in schools with healthy indoor air, increasing their productivity, improving their education and attendance, and increasing their chances for success in school and in the future.
- Employees could work in buildings with healthy indoor air, increasing worker productivity and decreasing sick days and workers' compensation claims.
- Disability claims would drop significantly, reducing the cost and administrative burden of the rapidly increasing number of social security and private employer disability cases.
- Poor indoor air quality situations would be handled correctly, enabling business owners and landlords to properly remediate and remove contaminants, and prevent homeowners, tenants and employees from losing their homes and jobs as well as their lifetimes of achievements.

In other words, we would create a healthier, more productive society worldwide.

Throughout this paper, we will discuss many indoor air contaminants. When evaluating the impact of indoor air contaminants, it is important to consider all of the possible sources, as well as the acute and chronic health effects.

Indoor Air Contaminants

There are many types of indoor air contaminants. When evaluating the impact of indoor air contaminants, it is important to consider all of the possible sources and the acute and chronic health effects.

This paper focuses on indoor contaminants--excluding mold, mycotoxins and related contaminants in water-damaged buildings. To learn more about those contaminants, read our paper titled ‘Molds, Mycotoxins and Related Contaminants in Water-Damaged Buildings.’”

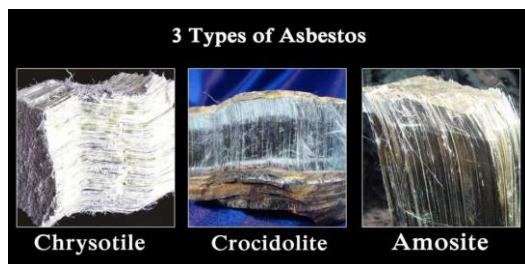
When evaluating the impact of indoor air contaminants, it is important to consider all of the possible sources and the acute and chronic health effects.

The list of indoor contaminants included in this paper are asbestos, chemicals, electromagnetic fields and radio frequencies, lead, particulate matter, products of combustion, radon and volatile organic compounds. This list is not exhaustive, but it discusses some of the major types of indoor contaminants that affect the air we breathe inside our homes, schools and businesses.

Asbestos

Asbestos has been used by humans for more than 4,500 years, but it became more widely used during the Industrial Age. The chemical properties of asbestos make it an effective fire retardant and electrical insulator even at high temperatures.

Asbestos is the commercial name given to six naturally occurring fibers. These six fibers belong to two subgroups (amphibole and serpentine), each differing in chemical formula and physical properties.¹⁶⁻¹⁹ All types share the property of mutagenicity (i.e., being able to induce malignant transformations in the deoxyribonucleic acid (DNA) of exposed cells). It is well established that all forms of asbestos are carcinogenic.²⁰⁻²³



Crocidolite (blue asbestos) was found in Africa in the early part of the 19th century, and amosite (brown asbestos) was discovered in South Africa. Amphibole forms of asbestos predominate as they are able to penetrate deeper into the lung. A

chronic foreign body reaction develops with resultant interstitial fibrosis due to a chronic inflammatory response. Crocidolite and amosite are two of the five amphibole types of asbestos, and they have the greatest potential for human health damage.

Chrysotile (white asbestos), the only serpentine mineral in this group, was discovered in 1876 in Quebec, Canada. It is capable of inducing multiple malignancies in persons exposed. According to the U.S. EPA, chrysotile accounts for approximately 95% of asbestos found in buildings in the United States.

Over 3,000 asbestos containing products have been used primarily as fire retardants and to insulate wiring and plumbing in homes, schools, offices and industrial plants. However, asbestos has been used in many other products.

While most exposure occurs with those who mine, fashion or use asbestos professionally, exposure from buildings can also occur. Asbestos fibers remain in the materials in which they are used, but aging can cause these materials to become friable and release respirable fibers into the air. It has also been found in drinking water due to the erosion of natural deposits, leaching from asbestos in landfills and the deterioration of asbestos-containing pipes.



Remodeling or renovations of buildings further disrupts these materials and allow asbestos fibers to infiltrate the air of indoor spaces. The most common diseases associated with chronic exposure to asbestos are asbestosis and pleural abnormalities (mesothelioma, lung cancer).²⁶⁻²⁷ Cancers associated with asbestos exposure affect the lungs, larynx, ovaries, pharynx, stomach, colorectum and other organs.

Mesothelioma

Mesothelioma is a cancer of the pleural lining of the lungs and other organs. Concomitant smoking increases the risk of all types, except mesothelioma, by a factor of 50 to 84.²⁸⁻³⁰

While there is overwhelming evidence that asbestos exposure is the cause of mesothelioma, there have been some cases where only indirect or low level acute exposure could be documented.^{31,32} One third of all mesothelioma victims have been found to have tissue asbestos fiber counts that did not exceed the levels associated with ambient background exposure suggesting that there is no “safe level” of exposure. In fact, according to the EPA, if there is a safe level of asbestos, it is currently below science’s ability to detect it.³³

Asbestosis

Asbestosis is caused by inhaled asbestos fibers instigating chronic inflammation and scarring or fibrosis in the lungs, typically after long term exposure such as with mining or asbestos manufacturing. Asbestosis typically presents as dyspnea, usually with exertion, and can progress to cor pulmonale [irreversible right-sided heart failure associated with pulmonary hypertension (increased blood pressure in the blood vessels of the lungs)].^{22,34}

This cancer presents as dyspnea, chest pain and weight loss. It may occur decades after exposure with an average latency of 35 - 40 years. Surgical and radiation interventions are

relatively ineffective, while newer chemotherapeutic agents offer some possibility for improvement.^{34,35} There is no cure for mesothelioma and survival rarely exceeds two years from diagnosis. However, a new study in 2016 showed the mesothelioma patients who receive chemotherapy survive longer than patients who did not.³⁶

Cross contamination (also known as secondhand or secondary exposure) has occurred in laundries where exposed asbestos and power plant workers' uniforms were washed.³⁷ These secondhand exposures have led to asbestosis in caregivers and family members of exposed employees. These individuals are often referred to as the "second wave" of asbestos victims. Similar cross contamination is found with other environmental toxins.

In the late 1970s, it was discovered that the industry had been aware, for more than 40 years, of the many health hazards of asbestos.³⁸ Sound familiar? This is another example of Big Business hiding the truth about the dangers of their products--- just like the tobacco companies hid the truth about the dangers of tobacco for more than 50 years.

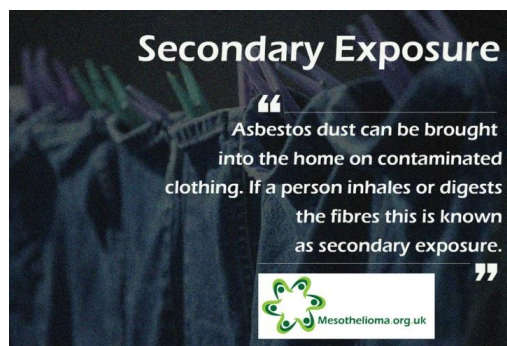
Asbestos has been banned in 55 countries worldwide.³⁹ Some of the recent announcements include:

- Canada issued new regulations under the Canadian Environmental Protection Act and updates to national building codes that will ban asbestos and asbestos-containing products by 2018.⁴⁰
- The President of Sri Lanka announced a total ban would take place in 2018.⁴¹
- The Ministry of Commerce in Oman announced their decision to "ban the import of asbestos was to ensure that no product which contains asbestos, or was manufactured with asbestos, would enter the country."⁴²

In the United States, asbestos is banned for "new uses" (products that have not historically contained asbestos), and certain asbestos-containing products (such as corrugated paper, rollboard, commercial paper, specialty paper and flooring felt) or asbestos-containing uses (such as asbestos pipe insulation and spray-applied asbestos materials).⁴³ However, asbestos has not been fully banned in the U.S. or in other countries such as China, Russia, India, Singapore, Taiwan, Mongolia and Ukraine.

Chemicals

There are thousands of harmful chemicals in our food, water, soil and air, and the number is rapidly increasing. This section will highlight some of the most common categories.



The authors of a new paper published in June 2017 provide an excellent introduction to this topic, as follows:

In a colossal “toxicological experiment” carried out over the last few decades, there has been the unprecedented production and release of tens of thousands of chemical agents into the environment without sufficient consideration for human safety and without credible testing to secure the absence of danger or harm. Such chemical pollutants are now ubiquitous and surreptitiously linger within our foods, our air, our water, and even within our bodies.⁴⁴

United Nations (Globally Harmonized System of Classification and Labelling of Chemicals)

In 2017, the United Nations published the seventh revised edition of a report that provides detailed information on the classification and labelling of chemicals. The first edition was published in 2003, with subsequent editions published in 2005, 2007, 2009, 2011 and 2013.

This system is known as the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Due to the worldwide use, sale and distribution of chemicals, they created one system that could be used throughout the world to classify and label these products.

It was a significant task to bring together the policies and practices of numerous countries around the globe to develop one harmonized approach. GHS was the culmination of more than a decade of work (beginning with a United Nations mandate in 1992). The participants in the process represented a multitude of countries, international organizations and stakeholder organizations from a vast number of disciplines. Early in the process, they agreed on 10 key principles of harmonization.⁴⁵ Here are three of those principles:



- (a) the level of protection offered to workers, consumers, the general public and the environment should not be reduced as a result of harmonizing the classification and labelling systems;
- (b) the hazard classification process refers principally to the hazards arising from the intrinsic properties of substances and mixtures, whether natural or synthetic;
- (c) in relation to chemical hazard communication, the safety and health of workers, consumers and the public in general, as well as the protection of the environment, should be ensured while protecting confidential business information, as prescribed by the competent authorities.⁴⁵

The U.S. EPA has not adopted the GHS approach. As stated on the EPA website:

EPA has not adopted GHS for pesticide product classification and labeling. In most cases, GHS hazard statements and pictograms should not appear on pesticide product labels sold and distributed in the United States.⁴⁶

Although the U.S. EPA has not adopted GHS, they acknowledged the benefits of using GHS for product labels, as follows:

If adopted, GHS will provide an internationally consistent basis for classifying chemical hazards. Once hazards are classified, GHS will also ensure that signal words, pictograms and hazard statements have the same meaning in all settings, domestically and internationally. This will simplify hazard communication and result in safer transportation, handling, and use of pesticides. This approach will benefit all countries that adopt GHS and should be particularly useful for countries without well-developed regulatory systems.⁴⁶

GHS also will reduce costly and time-consuming activities needed to comply with multiple classification and labeling systems, promoting more consistency in regulation and reducing non-tariff barriers to trade.⁴⁶

Currently, the U.S. EPA uses only two pictograms to warn of dangerous chemicals (i.e., a version of the skull and crossbones for the most severe categories of acute toxicity and a flame symbol for certain highly flammable pesticides).

Flame Retardants

Flame retardants are used in a wide variety of products including furniture, car seats, crib mattresses, changing table pads and other household and children's products. Manufacturers add these chemicals to slow the spread of flames in case they catch fire. Research on lab animals has shown that many of these chemicals cause cancer, alter hormones and damage brain cells.

A 2011 study found that 80% of the products tested contain chemical flame retardants can accumulate in babies' bodies. More than 1/3 of the products tested contained the same chemicals that were removed from children's pajamas in the late 1970s.⁴⁷

Those early flame retardant chemicals included polychlorinated biphenyls (PCBs), polybrominated diphenyl ether (PBDE) and Tris phosphate.

Because those early flame retardants have been restricted or phased out, alternative chemicals—organophosphate flame retardants (OPFRs)—are being used. However, these chemicals have also been found to be harmful.⁴⁸

Personal Care Products

Many of your common, every day personal care products contain harmful chemicals. These products include cosmetics, soaps, shampoos and other personal hygiene items. We will discuss just two of the chemicals found in personal care products.

1,4-dioxane

In 2007, the Environmental Working Group studied the ingredients in more than 27,000 personal care products. One chemical, known as 1,4-dioxane, was found in more than 28 percent of the products.⁴⁹

In three product groups for babies (bubble baths, shampoos and soaps), they found more than 55% of the products contained this chemical.⁵⁰

Contrary to industry statements, there are no regulatory standards that limit formaldehyde, 1,4-dioxane or most other toxic chemicals in personal care products sold in the United States. Other nations have stricter standards.⁵⁰

Canada has also banned this chemical from personal care products. In addition, since 2006, manufacturers must disclose all cosmetic ingredients and are required to register their products.⁵¹

The European Union (EU) has banned 1,328 chemicals from cosmetics (including 1,4-dioxane). The EU Cosmetics Directive was adopted in January 2003, and the most recent revision occurred in 2013.⁵¹

In comparison, the U.S. FDA has only banned or restricted 11 chemicals from cosmetics. Unlike the United States, EU law requires pre-market safety assessments of cosmetics, mandatory registration of cosmetic products, government authorization for the use of nanomaterials and prohibits animal testing for cosmetic purposes.⁵¹



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In April 2017, two senators petitioned the U.S. Food and Drug Administration (FDA) to prohibit the use of 1,4-dioxane in personal care products. The FDA says it has been monitoring levels of the substance in cosmetic products since the 1970s, amid concern from studies linking it to cancer. However, they have not taken action.⁵²

Oxybenzone

Oxybenzone is another harmful chemical found in many sunscreens and at least 567 other personal care products. A 2008 study by the U.S. Centers for Disease Control and Prevention (CDC) found that 97% of Americans are contaminated with this chemical. A companion study released one day earlier found this chemical is linked to low birth weight in baby girls whose mothers are exposed to oxybenzone during pregnancy.⁵³ However, the CDC still recommends the use of sunscreen with oxybenzone.⁵⁴ The U.S. Food and Drug Administration (FDA) has

delayed issuing final sunscreen safety standards for almost 40 years and still lists oxybenzone on the list of “acceptable active ingredients” in sunscreen products.⁵⁵

Pesticides

Pesticides are chemicals used to kill or limit the growth of numerous types of pests. Included in this grouping are herbicides (kill plants), fungicides (kill fungi), insecticides (kill insects) and numerous other classes. They are designed to disrupt biological systems.^{56,57} Pesticides are used extensively in farming and are also used in homes, schools and businesses. Ten of the twelve most dangerous organic chemicals are pesticides.

Pesticides have been used to control mosquitoes to reduce the spread of diseases such as malaria and yellow fever. However, approaches to the treatment of mosquitoes and other health threats often have included excessive and injudicious use of pesticides rather than appropriate vector control.

There are more than 17,000 pesticide products on the market. Many of those are approved through “conditional registration”—a regulatory loophole that allows products on the market quickly without thorough review.⁵⁸

In addition to the widespread use of pesticides on agricultural lands, parks, schools and commercial and residential properties, pesticides are also found in household cleaners, hand soaps and swimming pools.

Individuals may be exposed to pesticides through both direct and indirect routes. Direct exposure occurs to individuals who personally apply pesticides in agricultural, occupational, or residential settings and is likely to result in the highest levels of exposure, whereas indirect exposures occur through drinking water, air, dust, and food and represent routes of long-term, generally low-level exposures. Indirect exposures may occur more frequently than direct pesticide application.⁵⁹

Pesticide exposure has been linked to numerous health effects including non-Hodgkin’s lymphoma, Parkinson’s disease, autism, leukemia, fetal death, birth defects, neurodevelopmental disorders and cancer.⁵⁹⁻⁶⁷

Pesticide poisoning is another significant health issue caused by exposure to pesticides.^{68,69} Symptoms include nausea, vomiting, headaches, rashes, eye irritation, fatigue, weakness, cramps, tremors, seizures and death. As stated by the World Health Organization:

Cases of acute pesticide poisoning (APP) account for significant morbidity and mortality worldwide. Developing countries are particularly susceptible due to poorer regulation,

Cases of acute pesticide poisoning (APP) account for significant morbidity and mortality worldwide. Developing countries are particularly susceptible due to poorer regulation, lack of surveillance systems, less enforcement, lack of training and inadequate access to information systems.

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Many individuals and workers who experience health effects from APP may never present to a health-care provider due to distance from a medical facility, lack of resources, economic factors, fear of job loss or other reasons. Some health-care providers may be unaware of the relationship between pesticide and illnesses and fail to diagnose or report the incident properly. Additionally, some pesticides may not be properly mixed, prepared, applied, labelled or registered, making the determination of the agent of exposure difficult.⁶⁸

It is important to note that although some pesticides have been banned or restricted, they are still being used---either illegally or through the “Critical Use Exemption.” For example, the U.S. EPA offers a Critical Use Exemption for methyl bromide (another type of pesticide) when users have no technically and economically feasible alternatives and where the lack of methyl bromide will result in a significant market disruption.⁷⁰

According to a 2009 report, over 1 billion pounds of pesticides are used in the United States and 5.6 billion pounds are used worldwide.⁷¹

Although attempts to reduce pesticide use through organic agricultural practices and the use of other technologies to control pests continue, exposure to pesticides occupationally, through home and garden use, through termite control or indirectly through spray drifts and through residues in household dust, and in food and water are common. The U.S. Department of Agriculture



has estimated that 50 million people in the United States obtain their drinking water from groundwater that is potentially contaminated by pesticides and other agricultural chemicals. Children from 3-6 years old received most of their dermal and non-dietary oral doses from playing with toys and while playing on carpets which contributed the largest portion of their exposure.⁷¹

Other countries have banned or restricted many types of pesticides. However, the United States still allows the use of these five---neonicotinoids, paraquat, 1,3-Dichloropropene, glyphosate and atrazine.

The following information provides a brief discussion of only three common pesticides. There is a vast amount of information available from other sources on the 17,000 pesticides currently in use.

Chlorpyrifos

This chemical is found in Dow Chemical's pesticide named Dursban and is one example of a pesticide known as organophosphates. Chlorpyrifos can affect the development of the cortex which helps govern intelligence, personality, muscle movement and other brain functions.

The U.S. Environmental Protection Agency (EPA) banned chlorpyrifos for resident use in 2011, but it still allows farmers and golf course owners to use it so workers and customers are still being exposed. However, the EPA says they are supposed to use personal protective equipment when applying it and restrict entry into the treated areas for 1-5 days.⁷² So, is it safe to re-enter the treated area after 1 day, or do you need to wait 5 days?

The EPA recently tried to completely ban chlorpyrifos, but the new EPA administrator, Scott Pruitt, denied the ban on March 29, 2017.⁷³

Research has shown that household use of organophosphates is associated with an increased risk of Parkinson's disease (PD). The researchers found:

- frequent use of household pesticides increased the odds of developing PD by 47%
- frequent use of products containing organophosphates increased the odds of PD by 71%
- frequent use of organothiophosphate use almost doubled the odds of PD⁷⁴

Another type of "indoor environment" affected by organophosphates is the cabins inside airplanes. Organophosphates are added as a lubricant in aircraft engine oil and are included in the "bleed air" that is mixed inside the aircraft with recirculated cabin air. This creates a condition known as aerotoxic syndrome.⁷⁵⁻⁷⁷

Although the air from the turbine engines of commercial jet aircraft is used chiefly for propulsion some is also used to refresh and replenish air in the cabin. As a result of oil-seal leakage, pyrolysed engine oil or lubricating oil can contaminate cabin air via the aircraft's ventilation system, and flight crew and passengers can then inhale the combusted fumes. Exposure to emissions from cabin air, whether polluted or not, is associated with certain health risks. This phenomenon is known as the aerotoxic syndrome or 'cabin contamination'.⁷⁷

On some occasions, aircrew and pilots have felt so overwhelmed/incapacitated by fumes they have had to make an emergency landing.⁷⁸

Of note, the Boeing 787 Dreamliner is the only aircraft that does not circulate bleed air in the cabin. Instead, they use electrically-driven compressors taking air directly from the atmosphere.⁷⁵

Due to limited data, underreporting by airlines and employees, and the airline industry's refusal to acknowledge the problem despite numerous scientific studies and victim reports, there is still some debate about the exact cause of aerotoxic syndrome. However, it is important to note

that causation has been proven in numerous lawsuits brought by airline employees. In addition, the airline industry has quietly “admitted” the problem by introducing the new Boeing 787 that does not use bleed air inside the cabin.

As stated in a 2016 research paper, “it is imperative that we get a definitive answer to the question of whether exposure to engine oil fumes on board commercial aircraft causes ill health.”

It is surprising that, to date, no substantial efforts have been made by government or industry to establish the levels of chemical contaminants which enter the aircraft during a fume event or to establish the impact of cumulative, low level exposure over time. Injury might be preventable if contamination detection and bleed air filtration systems were installed in all commercial aircraft. While the existence of a relationship between contaminated cabin air and ill-health may be a potentially expensive and inconvenient truth; the costs of ignoring the possibility of such a relationship are too high to ignore.⁷⁸

This discussion highlights the importance of being aware that in addition to the viruses, bacteria, fragrances, formaldehyde, carbon dioxide and other contaminants present inside airplanes,⁷⁹ the use of chemicals/pesticides in the fuel is also a concern.

Glyphosate (Monsanto’s Roundup)

Another pesticide that is often cited in the headlines is Monsanto’s Roundup weed killer. The main ingredient in Roundup is glyphosate which has been restricted or banned in many countries (including Europe, Canada, Brazil, Sri Lanka, Bermuda, Sweden, France and the Netherlands). However, it is still being used in the United States. In fact, glyphosate has the highest global production volume of all herbicides.⁸⁰

In 1985, the U.S. EPA originally classified glyphosate as “possibly carcinogenic to humans.” However, in 1991, the EPA changed the classification to “evidence of non-carcinogenicity in humans.”⁸⁰

A 2013 research paper links glyphosate to the increase in celiac disease and gluten intolerance.

Celiac disease, and, more generally, gluten intolerance, is a growing problem worldwide, but especially in North America and Europe, where an estimated 5% of the population now suffers from it. Symptoms include nausea, diarrhea, skin rashes, macrocytic anemia and depression. It is a multifactorial disease associated with numerous nutritional deficiencies as well as reproductive issues and increased risk to thyroid disease, kidney failure and cancer. Celiac disease is associated with imbalances in gut bacteria that can be fully explained by the known effects of glyphosate on gut bacteria.⁸¹



In 2015, the World Health Organization concluded that glyphosate is “probably carcinogenic to humans.” Tests show that glyphosate also causes DNA and chromosomal damage in human cells.⁸⁰

As noted above, glyphosate has been restricted or banned in several countries. However, there has been no change in U.S. government policy. Glyphosate is still being sold and used in the United States.

Methyl Bromide

This pesticide is used to control pests, insects, weeds and fungi. It is also used to treat imported goods such as grapes, asparagus and logs. Methyl bromide is toxic and damages the ozone layer. It can cause central nervous system and respiratory system failures and can harm the lungs, eyes and skin.

Methyl bromide was the cause of pesticide poisoning in a story involving a Delaware family that was on vacation in the U.S. Virgin Islands. The parents became ill, and the teenage sons went into comas after being exposed to methyl bromide at a vacation resort.⁸² The father is still paralyzed and unable to speak and has tremors. The wife suffered seizures.

The U.S. EPA and the U.S. Justice Department investigated the case. In March 2016, the EPA reached a plea deal agreement with Terminix resulting in a \$10 million fine for illegally using this chemical.⁸³

In February 2017, the U.S. Justice Department filed a lawsuit against Terminix for the incident in the Virgin Islands and at least 70 other instances of illegal fumigation.⁸⁴ Terminix also agreed to pay \$87 million to the Delaware family. The \$87 million includes \$10 million of criminal fines.⁸⁵

United Nations Special Report on Pesticides (2017)

On January 24, 2017, the United Nations issued a special report on pesticides. They make it clear that pesticides are inflicting damage on human health and ecosystems around the world.

The assertion promoted by the agrochemical industry that pesticides are necessary to achieve food security is not only inaccurate, but dangerously misleading.⁸⁶

The report discusses the catastrophic effects of pesticides on human health and our environment, as follows:

Hazardous pesticides impose substantial costs on Governments and have catastrophic impacts on the environment, human health and society as a whole, implicating a number of human rights and putting certain groups at elevated risk of rights abuses.⁸⁶

Hazardous pesticides impose substantial costs on governments and have catastrophic impacts on the environment, human health and society as a whole.

The United Nations recommends safer options for pest control such as agroecology which is mentioned in the next section.

Safer Options for Pest Control

There are safer options such as organic or natural products (not made from chemicals). This approach is often referred to as Agroecology or Integrated Pest Management (IPM).

Agroecology

Agroecology is the science behind sustainable farming. It combines scientific inquiry with place-based knowledge and experimentation which emphasizes knowledge-intensive, low cost, ecologically sound and practical approaches.^{61,86}

A rise in organic agricultural practices in many places illustrates that farming with less or without any pesticides is feasible. Studies have indicated that agroecology is capable of delivering sufficient yields to feed the entire world population and ensure that they are adequately nourished.⁶¹

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an ecological approach using multiple strategies of pest control while minimizing the use of potentially toxic pesticides.⁸⁷

Many organizations, schools and government agencies have adopted the principles of Integrated Pest Management.

The U.S. federal government has mandated IPM on all federal properties since 1996 by Section 136r-1 of Title 7, United States Code, cited in Title 41 of the Code of Federal Regulations (102-74.35).⁸⁸

In connection with that mandate, the U.S. General Services Administration (GSA) has distributed IPM guidance to more than 70 federal agencies, 2 foreign governments and about 50 public agencies in 17 states.⁸⁸

Another example of widespread use of IPM is the statewide program that has been implemented in California.

The University of California Statewide IPM Program (UC IPM) helps residents, growers, land managers, community leaders, and other professional pest managers prevent and solve pest problems with the least unintended impacts on people and their surroundings.⁸⁹



Another example is the U.S. Centers for Disease Control and Prevention (CDC). The CDC's Indoor Environmental Quality Policy limits or prohibits several types of indoor air contaminants including pesticides. Here is the section of their policy relating to pesticides:

Pest management, for both buildings and lawn care, will emphasize non-chemical management strategies whenever practical, and the least-toxic chemical controls when pesticides are needed. Integrated Pest Management practices must be utilized.⁹⁰

Additional discussion about the CDC's Indoor Environmental Quality Policy can be found later in this paper in the section on Fragrances.

Phthalates

Phthalates are man-made chemical compounds that are primarily used as plasticizers (i.e., substances added to plastics to increase their flexibility, transparency, durability and longevity), but they are also added to food, beverages, spices, drugs, fragrances, air fresheners and many personal care products.

Numerous studies have shown that phthalates are harmful and can cause multiple health effects including impaired sperm quality and motility, respiratory symptoms, thyroid problems, and negative effects on prenatal development, reproductive hormones and pregnancy outcome.

Phthalates are often mentioned in the news in connection with PVC (polyvinyl chloride). Phthalates and/or PVC products have been restricted or banned from toys and children's products in several countries including the European Union, France, Denmark, Austria, Finland, Germany, Canada, Japan, Mexico, Argentina, Greece, Italy, Norway and Sweden.⁹¹

Several states and local governments in the U.S. have also banned certain types or uses of phthalates. In addition, many hospitals and healthcare facilities in the U.S. are reducing or phasing out the use of products with phthalates.

The Consumer Product Safety Bill of 2008 included a ban on certain phthalates in children's toys. A few years later, in 2014, the U.S. Consumer Product Safety Commission (CPSC) issued a report that provided a summary of numerous studies regarding the health effects of phthalates. The CPSC also provided recommendations about banning several types of phthalates.⁹²



Phthalates are also included in a large category of chemicals that can cause endocrine disruption. As noted in our paper on the “Global Burden of Indoor Air Contaminants,” a 2016 report estimated the cost of healthcare and lost earnings due to illness caused by endocrine-disrupting chemicals at \$340 billion in the U.S. They also provided an estimate of these same costs for Europe, showing an annual cost of \$217 billion.⁹³

Solvents

Solvents are chemical products that are used to dissolve other compounds. These chemicals can cause a sudden loss of consciousness if inhaled and can also cause long-term health effects.

There are many different types of solvents including acetone, benzene, ethanol, hexane, methanol, toluene, trichloroethylene and xylene.

Another one is 1,4-dioxane which was discussed above in regard to personal care products. We will provide a brief discussion of one type of solvent-- Trichloroethylene (TCE).

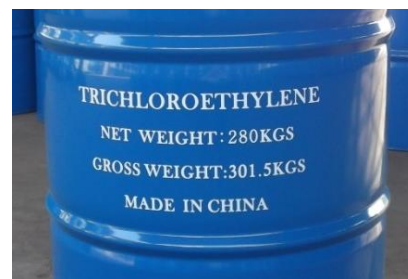
Trichloroethylene (TCE)

Trichloroethylene (TCE) is an industrial solvent used primarily to make hydrofluorocarbon chemicals. TCE is primarily used as a metal degreasing agent to maintain military equipment, so it is frequently found in the groundwater at many military sites. It is also used as a refrigerant and as a spot remover in dry cleaning operations and can be found in some aerosol cleaning products.

TCE was added to the list of carcinogens in the “U.S. Department of Health and Human Services 14th Report on Carcinogens” in 2016.⁹⁴

In December 2016 and January 2017, the U.S. EPA proposed two rules to ban TCE in vapor degreasing, in commercial and consumer aerosol degreasing, and as a spot cleaner in dry cleaning.

These proposed regulatory actions follow a June 2014 TSCA Work Plan Chemical Risk Assessment for TCE that identified serious risks to workers associated with this TCE use and concluded that the chemical can cause a range of adverse health effects, including cancer, developmental and neurotoxicological effects, and toxicity to the liver.⁹⁵



However, in July 2017, house lawmakers are “quietly urging the administration to abandon proposed U.S. EPA regulations that would ban certain uses of three dangerous chemicals and restrict the number of hazardous waste reviews done by the Department of Health and Human Services.”⁹⁶

Once again, Big Business is choosing profits over health.

"The House is now telling the agency, 'Forget about that risk and defer any possible action on this chemical for years into the future,'" said Richard Denison, lead senior scientist at the Environmental Defense Fund (EDF). "It's one more example of private interests trumping public health protections of the most basic sort."⁹⁶

Public health advocates are expressing outrage that lawmakers have urged the EPA to slow-walk the worker protections — just as industry groups requested.⁹⁶

Chemical Sensitivity

Because of harm caused by chemicals in our environment and in commercial and consumer products, there are an increasing number of people developing a condition commonly known as chemical sensitivity. Some of the other names for this illness are multiple chemical sensitivity, Toxicant-induced Loss of Tolerance (TILT), environmental intolerance, sensitivity-related illness and Cumulative Organic Chemical Hyper-Toxicity.⁹⁷⁻¹⁰⁴

Dr. William Rea, a pioneer in this field, wrote a paper in 2016 on the “History of Chemical Sensitivity and Diagnosis.” He discusses the connection between chemical sensitivity and other environmental exposures. Here is an excerpt from the paper:

Histories of mold, pollen, dust, food, chemicals, and electromagnetic field (EMF) sensitivities are the major categories of triggers for chemical sensitivity. They are tied together by the coherence phenomenon, where each has its own frequencies and identifiable EMF; therefore, they can be correlated.¹⁰⁴

The principles of diagnosis and treatment depend on total environmental and total body pollutant loads, masking or adaptation, bipolarity of response, and biochemical individuality, among others.¹⁰⁴

A 2013 research paper by Dr. Stephen Genuis, another leader in this field, states:

Escalating numbers of people throughout the world are presenting to primary care physicians, allergists, and immunologists with myriad clinical symptoms after low-level exposure to assorted everyday chemicals such as smoke, perfumes, air fresheners, paints, glues, and other products.¹⁰²

The emerging problem of ubiquitous adverse toxicant exposures in modern society has resulted in escalating numbers of individuals developing a chemical sensitivity (CS) disorder. As usual in medical history, iconoclastic ideas and emerging evidence regarding

Histories of mold, pollen, dust, food, chemicals, and electromagnetic field (EMF) sensitivities are the major categories of triggers for chemical sensitivity. They are tied together by the coherence phenomenon, where each has its own frequencies and identifiable EMF.

novel disease mechanisms, such as the pathogenesis of CS, have been met with controversy, resistance, and sluggish knowledge translation.¹⁰²

The American Academy of Environmental Medicine (AAEM) has published a position statement on Chemical Sensitivity. Here are some excerpts:

Chemical sensitivity is a physical reality that our society will have to recognize and address. The word "sensitivity" implies that tiny exposures lead to big problems. The 90,000 chemicals commonly circulating in our modern world appear to be causing considerably more problems for humans than are typically recognized.¹⁰⁵

Chemically sensitive persons, when reacting to even small chemical exposures, suffer with various symptoms that range in intensity from being unpleasant to being temporarily or even permanently disabling.¹⁰⁵

Only too frequently this condition is unrecognized as it progressively leads to poor health, reduced activity, stressed social relationships and reduced job productivity.¹⁰⁵

Common incitants include pesticides; natural gas; petroleum-based solvents like toluene and benzene; volatile organic compounds (VOCs) like formaldehyde; heavy metals like mercury and aluminum; molds and the potentially dangerous mycotoxins they release; tobacco smoke; the phthalates and other endocrine-disrupting compounds, like bisphenol A, found in plastics; flame retardants like PBDEs; and automobile exhaust fumes; synthetic fragrances like perfumes, air fresheners, and other "pleasant-scented" products; newspaper print; personal care products; laundry detergents and fabric softeners; household cleaners; and fluoride-containing water and toothpaste, etc.¹⁰⁵

Additional information about the health effects of chemicals can be found in thousands of reports and numerous websites.

Electromagnetic Fields (EMF) and Radio Frequencies (RF)

The use of EMF and RF devices is growing exponentially. These devices transmit wirelessly using Electromagnetic Fields (EMF) and Radio Frequencies (RF). They are NOT safe and are harmful to adults, children, animals and plants.

What is the difference between EMF and RF?

Electromagnetic fields or EMFs usually refer to low frequency magnetic fields. Magnetic fields are created by electricity flowing through wires. Common EMF sources are power and transmission lines, internal building wiring system, electrical panels, transformers, motors and appliances. Elevated EMF fields are often caused from wiring problems, stray current or bad grounding.¹⁰⁶



Radio Frequency Radiation or RFs usually are high frequency electromagnetic radiation due to the use of wireless equipment, devices and data transmission. Common RF sources are radio and television transmissions, cell towers and antennas, portable phones, cell phones, wireless computer networks (WLAN) and radar equipment.¹⁰⁶

The corporations that develop and sell products and equipment using EMF/RF will tell you their products are safe because they meet the FCC guidelines. This is not acceptable and not valid because the current FCC safety limits (established in 1985—more than 30 years ago) are based on thermal exposure alone. The FCC guidelines are ten times more lenient than what the Environmental Protection Agency (EPA) would have permitted to protect the general population from the health hazards of RF/microwave radiation.¹⁰⁷

The current FCC safety limits were established in 1985 and are based on thermal exposure alone. These limits ignore the non-thermal effects and are seriously outdated.

In the late 1980s, the EPA radiation division, staffed with practicing biologists and epidemiologists, decided on a safe limit for human exposure. Before the announcement was made, industry intervened, federal funding for that division of the EPA was cut, and the FCC was given the task of setting the RF/microwave guidelines for the public.¹⁰⁷

The FCC, made up of bureaucrats and engineers, had no experience or training in setting “health related” guidelines. Therefore, from the beginning, FCC guidelines were set at a limit that was too lenient to protect the general population.¹⁰⁷

As stated in the International EMF Scientist Appeal:

Numerous scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines.

Numerous scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life.¹⁰⁸

In 2013, the U.S. Government Accountability Office asked the FCC bring its public radiation exposure guidelines in line with current science. As a result, the FCC voted to “advance its review of its various rules pertaining to the implementation of the National Environmental Policy Act (NEPA) requirements related to radiofrequency (RF) emissions from radio transmitters.” They opened a new docket (ET Docket No. 13-84) to consider the RF exposure limits.¹⁰⁹ However, there has been no change in the FCC’s recommended RF exposure limits.

A 2015 report, published by the Edmond J. Safra Center for Ethics at Harvard University, explains the lack of progress by the FCC. The report is titled “Captured Agency: How the Federal Communications Commission is Dominated by the Industries it Presumably Regulates.”¹¹⁰

The report describes how “the wireless industry has unlimited access to shape FCC policies at the expense of public interests. The public interests mentioned included consumer safety, privacy, health and consumer wallets.”¹¹¹

As explained in the Harvard report, the Telecom Act of 1996 contains a federal preemption that prohibits state and local governments from limiting antennas in their communities on health or environmental grounds. The public has very little knowledge of this fact and is routinely surprised to learn it when residents protest antennas near schools, hospitals, retirement homes, etc., only to find there is little communities can do to prevent antennas and towers going up, because of provisions of this Act.¹¹¹

Again and again, Congress and the FCC have extended the wireless industry carte blanche to build out infrastructure no matter what the consequences to local communities.¹¹¹

The report also mentions how the telecom industry is following the same playbook used by the tobacco industry (to deny the health effects of tobacco), including:

- Obtuse refusal to examine the health evidence
- Misleading about scientific consensus and publishing contradictory science
- Undermining credibility of scientists and cutting scientist funding
- Hyper-aggressive legal action and bullying
- Industry control of Congressional committees
- Revolving door between industry and regulator
- Enormous sums spent on direct lobbying and via associations
- Hard money and soft money contributions to elected officials and government employees¹¹¹

This same strategy has been used by Big Business for decades to delay, deny and hide the truth about harmful products and substances. See our paper on “Naysayers and Deniers” for additional information about the strategy used by the tobacco industry and other Big Business organizations.

A brief summary regarding cell phones and cancer

The World Health Organization’s 10-year study of human use of mobile phones concluded there is an increased risk for malignant brain tumors among the heavier mobile phone users, particularly where it is used mostly on one side of the head.¹¹²

The 2010 Interphone mega-study of cancer in humans using mobile phones found higher cancer risk, but at that time, there was little animal testing to support the risks identified in humans.¹¹²

Although many corporations and government agencies are still denying the risks of cell phones, it is important to highlight the May 2016 announcement from the National Toxicology Program (NTP) under the National Institutes of Health. They completed the largest-ever animal study on cell phone radiation and cancer. The results confirm that cell phone radiation exposure levels within the currently allowable safety limits are the “likely cause” of brain and heart cancers.

Now, this NTP study has shown statistically significant risks with a dose-response relationship to the amount of exposure. It proves that non-ionizing radiation can plausibly cause cancer, not just ionizing radiation like x-rays, and puts to rest the traditional scientific argument that cell phone radiation can’t do harm.^{113,114}

Our paper titled “Electromagnetic Fields and Radio Frequencies (EMF and RF)” provides a detailed discussion of the health effects of several sources of EMF and RF including cell towers, smart meters, cell phones, cordless phones, personal computers, Bluetooth devices, and many other wireless products and devices. It also includes recommendations from scientists on steps that need to be taken to reduce or eliminate our exposure to this harmful radiation.

Lead

The 82nd element on the periodic table is lead. Considered a heavy metal, lead has been used for thousands of years because it is quite malleable and melts at a relatively low temperature.

Lead is used in polyvinyl chloride (PVC) plastic, lead glass, mini-blinds, crayons, toys, backpacks, lunchboxes, metal candle wicks, zippers, ammunition, batteries, semiconductors, construction products, batteries, pewter and solders, spices and in glazes for painting ceramics. One well-known concern is lead paint that was used in homes prior to 1978.¹¹⁵⁻¹²⁰

Another use of lead is in fuel for some types of aircraft. Aviation gas, known as avgas, is used in aircraft that provide many services including business and personal travel, instructional flying, aerial surveys, agriculture, firefighting, law enforcement, medical emergencies, and express freight.

The World Health Organization’s 10-year study of human use of mobile phones concluded there is an increased risk for malignant brain tumors.



In May 2016, the National Toxicology Program completed the largest-ever animal study on cell phone radiation and cancer. It proves that non-ionizing radiation can plausibly cause cancer, not just ionizing radiation.

In 2013, the U.S. Federal Aviation Administration (FAA) laid out four initiatives aimed at eliminating lead from avgas. One of those goals is to have an unleaded fuel for aircraft by 2018. In a March 2016 update, the FAA selected two alternative fuels for further testing.^{121,122}

Lead poisoning

Poisoning from lead has been documented in several ancient civilizations and throughout many decades in modern history.¹²³⁻¹²⁹

Even now, in 2017, lead poisoning is still a significant problem. As stated in a recent article in the American Academy of Pediatrics news publication:

Despite considerable progress, our public health system is still failing to prevent children from being lead poisoned and the specter of lead poisoning continues to cast a shadow over the country: over 500,000 American children have a blood lead level of >5 µg/dL (>50 ppb); 23 million homes have 1 or more lead hazards; an unknown number of Americans drink water from lead service lines; and federal standards for lead in house dust, soil and water fail to protect children.¹³⁰

Lead exposures have occurred via inhalation, ingestion and even through skin contact. Inhalation is less of a concern since most countries have banned tetraethyl lead from automobile gasoline.¹³¹ Ingestion can come from numerous sources including hundreds of consumer products, produce grown in contaminated soils, some home remedies or from lead paint in homes built prior to 1978.

Lead is primarily stored in the blood, soft tissue and bones. Serum lead levels, erythrocyte protoporphyrin (EP) levels, appearance of red blood cell count (RBC) smears and physical exam findings can all detect or infer the acute presence of lead. Bone X-rays can be used as a measure of cumulative exposure.

Lead creates free radicals, interferes with DNA transcription, indirectly affects the integrity of cell membranes, decreases activity of certain white blood cells (WBC) and interferes with the metabolism of Vitamin D, bones, collagen and calcium. It may also cause excessive production of inflammatory proteins.

Symptoms of lead poisoning vary based on the chronicity of exposure and age of the patient. Adult acute poisoning may display muscle weakness, pain, headache, occasional encephalitis and memory loss. Children with acute lead exposure exhibit learning disabilities, weight loss, constipation, kidney failure, abdominal pain with vomiting and lethargy.¹³²⁻¹⁴⁴



Chronic exposure in children and adults often shows very subtle symptoms which may gradually become pronounced. Typically, short-term memory loss, concentration deficits, stupor, abdominal pain, loss of coordination and numbness or tingling in the extremities, as well as fatigue, headaches, anemia and sleep disturbances, are found in chronically exposed adults.¹³²⁻¹⁴⁴

Similarly exposed children often refuse play, become excessively active or develop behavior problems. Hearing loss and tooth decay are also seen. Studies have shown that greater incremental loss in intelligence quotient (IQ) points in children occurs at lower levels than for adults.¹³²⁻¹⁴⁴

No safe level of lead exposure has been determined. Prevention is the best treatment and most cases of poisoning are preventable. Screening programs exist for U.S. children.

Treatment of acute lead poisoning (increased blood lead levels and significant symptomatology) is by chelation with correction of other associated mineral deficiencies. The longer a person has been exposed, the less likely central nervous system deficits will correct.

U.S. Department of Housing and Urban Development (HUD)

Reports of lead poisoning are on the rise throughout the country. Often the stories relate to lead paint in older homes.

Effective January 13, 2017, the U.S. Department of Housing and Urban Development (HUD) changed their reference level for lead blood levels to match that of the CDC. Both agencies now use 5 micrograms per deciliter.¹⁴⁵ This is a big step for HUD and will hopefully help protect children in HUD homes. However, chronic exposure may show only subtle symptoms that build over time, so parents and physicians must be watchful.

Previously, HUD had used a reference level of 20 micrograms per deciliter (4 times higher)--since the 1990s.

A March 4, 2016, article provided the estimated costs of lead poisoning in the U.S., as follows:

\$233 billion in lost lifetime earnings
\$146 billion in special education expenses
\$53 billion in medical care¹⁴⁶

Effective January 13, 2017, the U.S. Department of Housing and Urban Development (HUD) changed their reference level for lead blood levels to match that of the CDC.

Flint, Michigan in the News (Lead in the water)

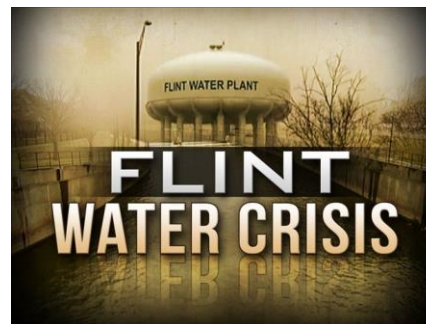
In 2015, there was extensive news coverage about lead in the water in Flint, Michigan. After the city switched its water source to the Flint River, residents became ill and tests showed elevated levels of lead in their blood. In the families tested, the lead levels had doubled or even tripled from the levels prior to the switch.

The city has started a years-long process of replacing pipes all over the city, but people have been harmed and some have died. The tap water is not safe to drink.

In June 2017, five government officials in Michigan were charged with involuntary manslaughter and misconduct in office in relation to the Flint water crisis. Fifteen additional officials are also facing criminal charges. The investigation is ongoing.¹⁴⁷

U.S. EPA rule on lead in drinking water

In October 2016, the U.S. EPA issued a White Paper on revisions to the Lead and Copper Rule. This rule relates to levels of lead and copper in drinking water.



On January 19, 2017, they took the next step in the process and initiated a peer review of the draft scientific modeling approaches regarding health-based benchmarks for lead in drinking water. Peer reviewers met on June 27-28, 2017, and are currently preparing their final comments.¹⁴⁸

New regulations about lead in consumer products in Europe

The European Commission (EC) published a new regulation about lead in consumer products. Effective June 1, 2016, lead in consumer products cannot be equal to or greater than 0.05% by weight if those articles or accessible parts may be placed in the mouth by children. There are exemptions for certain products such as precious stones, keys, music instruments and a few others.¹⁴⁹

Particulate Matter

Solid matter which is suspended in a gas or liquid is called particulate matter (PM) and is also known as particulates, fine particles and soot. PM can be natural, such as ash from volcanoes, or manmade, from combustion of solid fossil fuels like coal.

PM can be dissolved into water or suspended in the air. Spherical particles 5 microns in diameter and smaller are called “respirable” and can reach the air sacs, or alveoli, of exposed persons’ lungs. PM often carry toxic agents on their surface, enabling them to deliver poisons to the surface of the deepest and most delicate structures of the lung.

Normal human red blood cells (RBC) average 5 to 7 microns in diameter and are comparable in size to the largest respirable PM. To understand how small these particles are, typically 3.5 to 5.3 million RBC are present in a single cubic centimeter (1 cc or 1 ml) of blood.

Inhaled particulates are classified by their size as this indicates where in the respiratory tract they can travel. Particles with an aerodynamic diameter of 10 microns or greater are filtered in the mouth and nose. Particles of 5 microns diameter and less can reach the alveoli, whereas

particles < 0.1 micron (nano-particles) can translocate through cell membranes and gain access to other organs in the body.¹⁵⁰⁻¹⁵³

Nanoparticles are less than 100 nm (nano-meters) and are being studied for use in several fields including biomedical, optical and electronics. A nano-meter is one billionth of a meter or 1/1000 of a micron. This rapidly expanding field of nanotechnology is exploring the use of nanomaterials for cancer treatment, bio detection of pathogens, tissue engineering and other applications.

In addition, there is also a lot of research on the effect of nanoparticles in our environment.¹⁵⁴⁻¹⁵⁶ For example, in a 2016 report on contaminants in a water-damaged home, they said:

Field studies of water-damaged homes have shown concentrations of nano-particulates in indoor dust that are at least 1000 times or greater than the indoor air mold spore counts. These particulates contain 1, 3-beta glucans and a variety of fungal proteins that include substrate enzymes as well as mycotoxins.¹⁵⁷



Sixty years of research by the National Institute for Occupational Safety and Health (NIOSH) has repeatedly demonstrated that respirable particles are invisible and unfilterable using any passive filtering device. Only self-contained breathing devices, such as SCUBA gear, can adequately protect from respirable particulates.

The next four sub-headings (Worldwide, China, Europe and United States) provide estimates of the impact of particulate matter. However, these statistics relate to only select pollutants. In most cases, the numbers represent only the impact of outdoor pollution. If indoor air pollution is included, it also represents only select pollutants. Either way, the total impact of all types of particulate matter is not included, but it does begin to illustrate the magnitude of the problem.

Worldwide

The International Energy Agency (IEA) released new estimates in June 2016. They said air pollution has become a major public health crisis leading to around 6.5 million deaths each year with many of its root causes and cures found in the energy industry.¹⁵⁸

Clean air is vital for good health. Yet despite growing recognition of this imperative, the problem of air pollution is far from solved in many countries, and the global health impacts risk intensifying in the decades to come.¹⁵⁸

No country is immune as a staggering 80% of the population living in cities that monitor pollution levels are breathing air that fails to meet the air quality standards set by the World Health Organization.¹⁵⁸

The report includes strategies for reducing air pollution which are tailored to various country circumstances. As they state, “The air quality outlook is not set in stone, but rather it is a policy choice.”¹⁵⁸

China

Researchers at the University of California, Berkeley, calculated that 1.6 million people in China die from polluted air. Earlier studies put the annual Chinese air pollution death toll at one to two million, but this is the first to use newly released air monitoring figures.¹⁵⁹

Europe

In Europe, around 467,000 deaths in 2013 were caused by air pollution.

In a 2013 report from the European Commission, they estimated the costs of air pollution as follows:

- total health-related external costs were in the range of EUR 330–940 billion
- direct economic damages of EUR 15 billion from lost work days
- EUR 3 billion from crop yield loss
- EUR 1 billion from damage to buildings

Two country-specific examples of the costs of illness from particulate matter are:

- In Bulgaria, costs for illness from coal power plants are estimated to be up to up to €4.6bn (\$4.8bn; £3.9bn) per year.
- In the United Kingdom, air pollution overall costs the economy more than £20bn per year - just under 16% of the NHS's annual £116bn budget.^{160,161}

United States

The U.S. experiences around 200,000 deaths each year due to air pollution from heavy industry, coal, electric power generation, cars, trains, ships, and commercial and residential heating.



Total health-related costs due to air pollution in Europe are estimated at EUR 330-940 billion.

In a recent report from Duke University, they estimate that 295,000 American lives could be saved if we reduce greenhouse gas emissions by 40% by 2030.¹⁶²

Filtering can sometimes remove water-borne PM, and controlling source exposure and optimizing ventilation may lessen airborne PM exposures.

Particulate matter in water-damaged buildings often contains mycotoxins, endotoxins, antigens, etc. from molds and bacteria. Additional information about biological particulate matter can be found in our paper on “Molds, Mycotoxins and Related Contaminants in Water-Damaged Buildings.”

Products of Combustion

Products of combustion are the end product that remains after the process of combustion. They are harmful to living and non-living matter. Some sources include carbon dioxide (CO₂), carbon monoxide (CO), kerosene, natural gas, nitrogen dioxide, solid cooking and heating fuels, tobacco smoke and e-cigarettes.

Carbon Dioxide (CO₂)

Carbon dioxide is a colorless, odorless gas. It is a waste product in our bodies and is also produced by burning fossil fuels. CO₂ is a greenhouse gas that contributes to the problem of global warming. It was previously used as an indicator of ventilation and was considered a problem in indoor air only at high levels of 5,000 parts per million or more. However, researchers have found that CO₂ is a direct pollutant that has negative effects on cognitive function.^{163,164}

In a 2017 research study on mice, they found that CO₂ causes inflammatory vascular injury. After exposing the mice for two hours, they found neutrophil and platelet activation and vascular leak in the brain, muscle and distal colon.¹⁶⁵

High levels of carbon dioxide can be found in buildings with poor ventilation. One example involves a school district in Indiana. After complaints about air quality at one of their schools, the public health department investigated. They found high levels of CO₂ and issued orders to the school to address the problem. The school district spent \$300,000 improving the air quality in that building and planned to spend up to \$4 million addressing air quality district wide.¹⁶⁶



Carbon Monoxide (CO)

Carbon monoxide (CO) is a colorless, odorless and tasteless gas which is responsible for the most common type of fatal indoor air poisoning in many countries.¹⁶⁷ Derived as a product of

incomplete combustion, CO is released from auto exhausts, cigarettes, malfunctioning gas appliances (water heaters, furnaces, ranges etc.), fireplaces and indoor solid fuel burning devices such as wood stoves.¹⁶⁸

CO competes effectively with oxygen for hemoglobin binding sites, reducing oxygen delivery to the tissues.¹⁶⁹ Exposure to 100 parts per million (ppm) can be hazardous to human health.¹⁷⁰

CO may cause acute and chronic poisoning syndromes. Acute toxicity starts as lightheadedness, confusion, headaches, vertigo and flu-like effects.¹⁷¹ As exposure progresses, significant cardiovascular and central nervous system (CNS) problems occur which can lead to death. Long-term sequelae are frequent and damage to an exposed fetus may also occur.

Diagnosis of acute poisoning is by a simple arterial blood test found at most hospitals, but one must have a high level of suspicion to order it. Treatment includes hyperbaric or 100% oxygen given over time. Low-level chronic CO poisoning is treated by some with high dose oxygen.¹⁷²⁻¹⁷⁵



A 2017 research paper discusses a case where a 22-year-old woman was found unconscious at her home. Her parents were found dead. They had a recent history of a dysfunctional furnace. Although the young woman had an initial carboxyhaemoglobin level of only 2.5%, she was presumed to have CO poisoning. She was given hyperbaric oxygen treatments and recovered to near normal functional status.¹⁷⁶

Chronic low level exposure can cause depression, confusion, memory loss and frank dementia. Chronic CO poisoning can cause Parkinsonian symptoms, Chemical Sensitivity (CS) and chronic fatigue.^{177,178} The easily inducible action of hemeoxygenase (HO-1) produces ferrous iron, CO and biliverdin from free heme.¹⁷⁷ Some chronic conditions increase free heme levels, potentially creating difficulty distinguishing increased endogenous production from chronic CO exposure.

A March 1, 2017, report provides a current summary of the health effects of CO poisoning, as follows:

Carbon monoxide (CO) poisoning affects 50,000 people a year in the United States. The clinical presentation runs a spectrum, ranging from headache and dizziness to coma and death, with a mortality rate ranging from 1 to 3%. A significant number of patients who survive CO poisoning suffer from long-term neurological and affective sequelae. The neurologic deficits do not necessarily correlate with blood CO levels but likely result from the pleiotropic effects of CO on cellular mitochondrial respiration, cellular energy utilization, inflammation, and free radical generation, especially in the brain and heart. Long-term neurocognitive deficits occur in 15–40% of patients, whereas approximately

one-third of moderate to severely poisoned patients exhibit cardiac dysfunction, including arrhythmia, left ventricular systolic dysfunction, and myocardial infarction.¹⁷⁹

Three additional products of combustion that affect indoor air quality are kerosene, natural gas and nitrogen dioxide.

Kerosene

Kerosene is a combustible hydrocarbon liquid that is often used for lighting, heating and cooking in low and middle-income countries. It is also used for heating in some developed countries such as Japan and some areas in Europe.

The World Health Organization states that kerosene use can lead to particulate matter levels that exceed WHO guidelines. There is some suggestion of increased risks of cancer, respiratory symptoms and infections.¹⁸⁰

Researchers conducted a study of 50,045 individuals, aged 40 to 75 years, from 2004 to 2008 that evaluated the relationship between household fuel use and cardiovascular disease mortality. The follow-up results showed that 3,073 participants died from cardiovascular, oncological and respiratory illnesses. The analyses revealed a significant increase in ischemic heart disease and a trend toward strokes. Researchers would like to see these results replicated worldwide in order to support efforts to reduce the use of kerosene.¹⁸¹



Natural Gas

Natural gas is a flammable gas used for heating and cooking. Common sources of natural gas are hot water heaters, furnaces and gas cook stoves. Natural gas can cause respiratory illness, worsen allergies and be harmful to those with environmental and chemical sensitivities.

The British Medical Journal reported in 1996 that the use of domestic gas appliances, particularly gas stoves, was linked to increased asthma, respiratory illness, and impaired lung function.¹⁸⁰

The Canada Mortgage and Housing Corporation (CMHC) Clean Air Guide in 1993 identified gas appliances as significant contributors to chemical contamination in the home. They recommended that gas appliances be replaced with electric ones to reduce indoor air pollution.¹⁸²

A 2014 paper on emissions from natural gas stoves says “gas stoves emit nitrogen dioxide (NO₂), carbon monoxide (CO), and formaldehyde (HCHO), each of which can exacerbate various respiratory and other health ailments.”¹⁸³

Researchers from Lawrence Berkeley National Laboratory and Stanford University, developed a simulation model to estimate gas stove emissions and the exposures experienced by different household members. Here is an excerpt from their conclusion:



Our results suggest that in homes using NGCBs without venting range hoods, a substantial proportion of occupants experience pollutant concentrations that exceed health-based standards and guidelines. Using simulations of Southern California households cooking at least once per week, we estimate that pollutant levels exceed ambient air quality standards for NO₂ and CO in 55–70% and 7–8% of homes during a typical week in winter.¹⁸⁴

They estimate that 12 million Californians could be exposed to high levels of NO₂ and CO in a typical week in winter from cooking on natural gas stoves.¹⁸⁴

Nitrogen Dioxide (NO₂)

Nitrogen dioxide (NO₂) is a gas that comes mainly from the burning of fossil fuels (coal, oil and gas). Other sources of NO₂ include tobacco smoke, kerosene heaters and unvented gas appliances such as stoves, clothes dryers and space heaters.¹⁸⁵

The entire population is exposed to NO₂ originating from ambient sources, both when people are outdoors and when they are in indoor environments into which ambient NO₂ has infiltrated. As they go through their day, some people also spend time in locations that have higher NO₂ concentrations as a result of releases from non-ambient sources (e.g., indoors in homes with gas stoves).¹⁸⁶

Potential health effects include aggravation of asthma symptoms, respiratory problems, lung cancer and leukemia.

In a 2013 study by researchers from Yale University, they investigated the effects of NO₂ on children with asthma. They found:

Asthmatic children exposed to NO₂ indoors, at levels well below the US Environmental Protection Agency outdoor standard (53 ppb), are at risk for increased asthma morbidity. Risks are not confined to inner-city children, but occur at NO₂ concentrations common in urban and suburban homes.¹⁸⁷

In a 2016 report by Health Canada, they focused on epidemiological studies but also considered toxicology studies of animal and controlled human exposure studies. They found:

The entire population is exposed to NO₂ originating from ambient sources, both when people are outdoors and when they are in indoor environments into which ambient NO₂ has infiltrated.



Other indoor sources of NO₂ are tobacco smoke, kerosene heaters and gas appliances.

In short-term controlled studies of asthmatic adults, exposure to near-ambient levels of NO₂ elicited a range of adverse respiratory effects, including decreased lung function, increased airway hyperresponsiveness (AHR), and airway inflammation. Most of these effects, as well as increases in asthma-related respiratory symptoms, were also associated with ambient NO₂ in epidemiological studies of asthmatic children. Respiratory symptoms in asthmatic children were also related to indoor NO₂ in several epidemiological studies, and interventions to reduce NO₂ from gas appliances in classrooms decreased respiratory symptoms.¹⁸⁶

Ambient NO₂ concentrations were significantly and independently associated with increased respiratory and asthma hospitalizations and asthma emergency room visits (ERVs) in numerous population-based epidemiology studies.¹⁸⁶

There are also epidemiological studies that show a link between long-term exposure to NO₂ and these same health effects. Although other co-occurring pollutants may also have a role in these exposures, the researchers concluded that “the overall evidence indicates there is likely a causal relationship between long-term exposures to current levels of ambient NO₂/NO_x and respiratory effects related to the development of asthma or allergic-related disease.”¹⁸⁶

In a research study published in May 2017, they evaluated the effects of six main pollutants in Shiraz (one of the largest cities in Iran). They analyzed data for 3,001 days starting from January 1, 2005, along with data on the number of deaths due to lung and blood cancers (leukemia). They found a direct, significant correlation between the mortality rate of leukemia and concentrations of nitrogen dioxide and carbon monoxide.¹⁸⁸

Solid Cooking and Heating Fuels

Many people around the world use solid fuels for cooking and heating. Solid fuels include the household combustion of coal or biomass (such as wood, charcoal, dung and crop residues). They are typically burned in poorly ventilated conditions which results in indoor air pollution that far exceeds national standards and international guidelines.



According to the World Health Organization’s website, they are currently updating their information about the impact of solid cooking and heating fuels.¹⁸⁹

A 2016 report estimates that approximately 3 billion people (or half of the world’s population) use biomass for cooking or heating. In China alone, 420,000 annual deaths are due to indoor air pollution caused by solid fuels.

These homes have very high levels of particulate matter and gaseous air pollutants such as carbon particles, iron, lead, cadmium, silica, phenols and free radicals, carbon monoxide (CO), nitrogen dioxide, sulfur dioxide, formaldehyde, hydrocarbon complexes, and other inorganic and organic substances which include polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds, and chlorinated dioxins.¹⁹⁰

Because there are many research papers available on this topic and because the World Health Organization is updating their information about solid cooking and heating fuels, we provided only a brief discussion of the impact of this indoor air pollutant.

Tobacco Smoke and E-Cigarettes

Tobacco smoke contains a toxic mix of more than 7,000 chemicals¹⁹¹ which are subsequently inhaled into the smoker's lungs and many of which are subsequently exhaled in the form of secondhand smoke.

Every day, on average, nearly 2,500 youth under age 18 smoke their first cigarette and nearly 400 youth under age 18 become daily smokers.¹⁹¹

Nicotine is the main ingredient in tobacco, but the tobacco plant itself contains other toxic chemicals including cadmium and lead.

Nicotine reaches your brain within 10 seconds after you inhale smoke. It has been found in every organ of the body, as well as in breast milk.¹⁹²

Nicotine reaches your brain within 10 seconds after you inhale smoke. It has been found in every organ of the body, as well as in breast milk.

Smoking harms your whole body. It increases your risk of fractures, dental diseases, sexual problems, eye diseases, and peptic ulcers. If you smoke, your illnesses last longer and you are more likely to be absent from work.¹⁹²

Smoking tobacco causes cancer, cardiovascular diseases, respiratory diseases, reproductive effects, and other harmful health effects. In addition to lung cancer, smoking causes many other types of cancer including cancers of the throat, mouth, larynx, nasal cavity, esophagus, stomach, pancreas, kidney, bladder, and cervix, as well as leukemia.^{192,193}

There is an increased risk of vision loss or blindness from smoking. Studies have shown that smoking causes an increased risk of macular degeneration, cataracts, glaucoma, diabetic retinopathy and dry eye syndrome.¹⁹⁴

Smoking also affects unborn babies, causing low birth weight, pre-term delivery and infant death. The following statements are included in warnings from the American Pregnancy Association:

When you smoke, so does your baby. Smoking during pregnancy is estimated to account for 20 to 30 percent of low-birth weight babies, up to 14 percent of preterm deliveries, and about 10 percent of all infant deaths according to American Lung Association.¹⁹⁵

Statistics about smoking. The following are a few key facts and statistics relating to the impact of tobacco smoke:

Worldwide

- Tobacco kills more than 7 million people each year. More than 6 million of those deaths are the result of direct tobacco use, while around 890,000 are the result of non-smokers being exposed to secondhand smoke.
- Nearly 80% of the world's more than 1 billion smokers live in low- and middle-income countries.¹⁹⁶



United States

- Smoking-related illness in the United States costs more than \$300 billion each year, including:
 - Nearly \$170 billion for direct medical care for adults
 - More than \$156 billion in lost productivity, including \$5.6 billion in lost productivity due to secondhand smoke exposure
- More than 480,000 people in the United States die from tobacco use each year.
- Smoking cigarettes kills more Americans than alcohol, car accidents, HIV, guns and illegal drugs combined.
- More than 20 million Americans have died because of smoking since 1964, including approximately 2.5 million deaths due to exposure to secondhand smoke.
- In 2014, tobacco companies spent more than \$9 billion marketing cigarettes and smokeless tobacco in the United States.
- During 2016, about 258 billion cigarettes were sold in the United States.¹⁹⁷⁻²⁰¹

Secondhand smoke (SHS), also known as environmental tobacco smoke (ETS), is generated by the incineration of tobacco products. It is a complex mixture of gases and particles which contains 93 known harmful and potentially harmful chemicals, including more than 70 carcinogens.^{202,203}

More than 126 million nonsmoking Americans continue to be exposed to secondhand smoke in homes, vehicles, businesses and public places.²⁰⁴ Most exposures to tobacco smoke occur in homes and workplaces. Secondhand smoke causes heart disease and lung cancer in

nonsmoking adults.²⁰⁵ More than \$156 billion in lost productivity, including \$5.6 billion in lost productivity due to secondhand smoke exposure.²⁰⁶

Almost 60% of U.S. children aged 3 to 11 years - or almost 22 million children - are exposed to secondhand smoke. Several health conditions, including sudden infant death syndrome (SIDS), respiratory infections, low birth weight infants and increased incidence of ear infections and developing asthma, are attributable to secondhand smoke. It is also a potent lung irritant and trigger of asthma exacerbations.^{192,194}

The American Cancer Society sums it up as follows:

There is no safe level of exposure to secondhand smoke (SHS). Any exposure is harmful. The only way to fully protect non-smokers from exposure to SHS indoors is to prohibit all smoking in that indoor space or building. Separating smokers from non-smokers, cleaning the air, and ventilating buildings cannot keep non-smokers from being exposed to SHS.²⁰⁶



Thirdhand smoke (THS) is the result of smoke gases and particles which linger in clothing and hair and on furniture, carpets, walls, drapes, vehicles and other surfaces.²⁰⁷ A 2014 study found that thirdhand smoke is just as deadly as firsthand smoke.²⁰⁸

Researchers are beginning to look at the possibility of health effects from these residues. Recent studies have linked thirdhand smoke to increased risk of asthma, breathing problems, learning disabilities and cancer.¹⁹⁵ The only way to protect nonsmokers from thirdhand smoke is to create a smoke-free environment.

E-cigarettes (electronic cigarettes) include e-pens, e-pipes, e-hookah, and e-cigars and are known collectively as ENDS – electronic nicotine delivery systems. They allow users to inhale an aerosol containing nicotine and other substances.

Unlike traditional cigarettes, e-cigarettes are generally battery-operated and use a heating element to heat e-liquid from a refillable cartridge, releasing a chemical-filled aerosol.

The following statistics are from the U.S. Food and Drug Administration (FDA):

- More than 3 million middle and high school students were current users of e-cigarettes in 2015
- Sixteen percent of high school and 5.3 percent of middle school students were current users of e-cigarettes in 2015, making e-cigarettes the most commonly used tobacco product among youth for the second consecutive year

- In 2013-2014, 81% of current youth e-cigarette users cited the availability of appealing flavors as the primary reason for use²⁰⁹

On May 10, 2016, the FDA finalized a rule extending its regulatory authority to cover all tobacco products, including E-Cigarettes and all other ENDS. FDA now regulates the manufacture, import, packaging, labeling, advertising, promotion, sale and distribution of ENDS.^{210,211} This was supposed to require the e-cigarette companies to register their products by 2018, and it also set a timetable relating to cigars, cigarillos and hookah.

However, on July 28, 2017, they put the brakes on those requirements and specifically gave the e-cigarette companies another four years to comply (and gave another three years to cigar companies).^{212,213}

This change in position toward e-cigarettes was a big disappointment to health advocates but was not a surprise. Dr. Scott Gottlieb, who was appointed to head the FDA in May 2017, was “expected to be friendly toward the e-cigarette industry since he previously held a financial interest in a vape shop called Kure.”²¹²

The July 28, 2017, announcement also said the FDA will “begin a public dialogue about lowering nicotine levels in combustible cigarettes.”²¹⁴

Some health proponents, however, expressed caution, pointing out that the nicotine-reduction proposal could take years to enact and could be derailed by major hurdles, including the significant lobbying power of the tobacco industry.²¹²



In positive news, the U.S. Surgeon General issued a groundbreaking report in 2016 concluding that e-cigarettes can expose users to several potentially harmful chemicals, including nicotine, carbonyl compounds and volatile organic compounds.²¹⁵

State and local governments are also taking action to protect their residents. Hundreds of cities, counties and states have passed laws that prohibit e-cigarettes everywhere that smoking is banned.

On Friday, July 21, 2017, the Court of Appeals for the District of Columbia upheld a law banning e-cigarettes on airplanes.²¹⁶ It was good news that the Court of Appeals upheld the law, but it should be noted that all airlines in the U.S. had already banned e-cigarettes on their planes.

On April 28, 2017, the World Health Organization addressed the issue of e-cigarettes in a report. They recommend that governments adopt regulations that designate indoor smoke-free areas as also vape-free areas. They note that vaping has already been banned in bars, restaurants and other workplaces in 25 countries.²¹⁷

Radon

Radon is a naturally occurring radioactive decay product of uranium and is found in the soil throughout the earth. It is a tasteless, colorless and odorless gas. As a dense inert gas, once released from the dirt, it tends to accumulate in basements and on the ground floor of buildings.

Radon is radioactive and accounts for the majority of background radiation humans receive. The ionizing radiation emitted is carcinogenic.²¹⁸⁻²²²

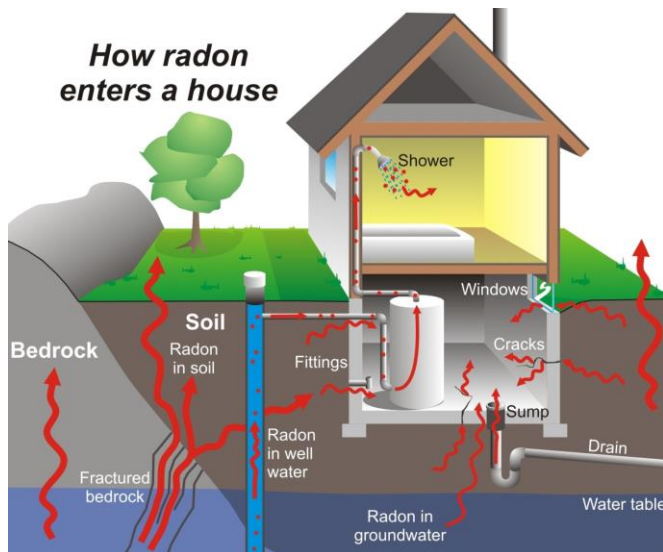
After smoking, radon exposure is the primary cause of lung cancer and is credited with the deaths of 20,000 people per year in the United States (U.S.) Radon-induced lung cancer costs the United States over \$2 billion dollars per year in both direct and indirect health care costs.²²² Smoking, with radon exposure, increases the likelihood of lung cancer.²²³⁻²²⁵

Typical exposure levels in homes are around 100 Bq/m³ (Becquerel/meter³) with a toxic range over 160 Bq/m³ (4 picocuries/Liter air or pCi/L), per the U.S. Environmental Protection Agency (EPA). European authorities have set higher tolerable limits for radon.

The U.S. Surgeon General and EPA recommend fixing homes with radon levels at or above 4 pCi/L. EPA also recommends that people think about fixing their homes for radon levels between 2 pCi/L and 4 pCi/L.²²²

A family whose home has radon levels of 4 pCi/L is exposed to approximately 35 times as much radiation as the Nuclear Regulatory Commission would allow if that family was standing next to the fence of a radioactive waste site.²²²

An elementary school student that spends 8 hours per day and 180 days per year in a classroom with 4 pCi/L of radon will receive nearly 10 times as much radiation as the Nuclear Regulatory Commission allows at the edge of a nuclear power plant.²²²



Home testing for radon is simple and inexpensive. Short-term testing gathers radioactivity data over 90 days or less while long-term testing can last up to a year. Numerous inexpensive and effective mitigation techniques are available.²²⁶⁻²²⁹

The U.S. EPA provides the following information on how to lower the radon level in your home.

There are several proven methods to reduce radon in your home, but the one primarily used is a vent pipe system and fan, which pulls radon from beneath the house and vents it to the outside. This system, known as a soil suction radon reduction system, does not require major changes to your home. Sealing foundation cracks and other openings makes this kind of system more effective and cost-efficient. Similar systems can also be installed in houses with crawl spaces. Radon contractors can use other methods that may also work in your home. The right system depends on the design of your home and other factors.²²⁸

In other words, excessive radon exposure should be totally avoidable.

Volatile Organic Compounds

Molecules of substances with high vapor pressure tend to flow from the liquid (or solid) state to a gaseous or evaporated state. Substances with a high vapor pressure at normal temperatures are said to be “volatile.” Volatile organic compounds (VOCs) are organic compounds (carbon based) which come out of their liquid (or solid) phase in significant degree to become gaseous, becoming part of the air people breathe.

Examples of toxic VOCs include butane, hexane, formaldehyde, benzene, limonene, pinene, isoprene, terpenes, xylene, styrene, toluene, chlorofluorocarbons, aliphatic hydrocarbons, carbon monoxide (CO), carbon dioxide (CO₂), freon, acetone, methane and hundreds of others.²³⁰⁻²³⁵

VOCs can come from a large number of sources. A few of those include air fresheners, synthetic fragrances, soaps, hand sanitizers, nail polish, solvents, paints, protective coatings, laundry supplies, dry cleaned clothes, citrus oil or pine oil cleaners, new furniture, copying and printing devices, cleaning supplies, aerosol sprays, refrigerant, degreasers, fuel, personal care products and many other sources. Evaporation of organic compounds from these sources indoors is called off-gassing. Other volatile chemicals, such as hydrogen sulfide (H₂S) in solution (as in sewer water), are also toxic and may come from the breakdown of organic materials.²³⁰⁻²³⁵

VOC levels can be from 5-1,000 times outdoor levels. Illness is usually not acute—but due to chronic exposures.

Long-term exposure to indoor VOCs can contribute to Sick Building Syndrome (SBS) and Building Related Illness (BRI). Illness is usually not acute—but due to chronic exposures. VOC levels can be from 5-1,000 times outdoor levels.

Health effects of VOCs include eye, nose and throat irritation, chest pain, brain fog, gastrointestinal problems, anxiety, visual disturbances, headaches, dizziness, fatigue, loss of coordination, nausea, memory impairment, damage to liver, kidney and central nervous system, immunological effects and cancer.²³⁰⁻²³⁵

Well-designed heating, cooling and ventilation (HVAC) systems can help lower indoor concentrations of VOCs. Consumer awareness and selection of natural or less-toxic products is also helpful. However, there needs to be significant improvement in labeling of products so ingredients and chemicals are clearly listed.

A 2017 study discussed indoor air quality in public utility environments (i.e., museums, libraries, temples, churches, schools, offices, hospitals and elderly care centres). They acknowledged that research on indoor air in public places is mostly focused on VOCs or secondary pollutants caused by an interaction with VOCs.²³⁶ They discuss the need for regulations and guidelines, and the importance of developing tools, techniques and methods for measures chemical compounds in indoor environments. The following excerpts are from their conclusion:

The analysis of literature data on indoor air quality in various public utility premises leads to the conclusion that regardless of the place or region where research is conducted, the problem with the occurrence of elevated concentrations of chemical compounds in indoor air is still valid and remains unsolved in many regions.²³⁶

Work should be started from scratch by choosing a suitable location for an enclosed space, designing an appropriate ventilation system and filters and choosing suitable construction and structural elements as well as equipment and finishing materials. All of these activities should also take into account the intended use of the enclosed space, the frequency of its use, the number of users and potential pollutants which can be present in indoor air and have a distinct influence on users' health and comfort.²³⁶

The following sections provide information on specific sources of VOCs. Discussion of VOCs from biological contaminants is provided in our paper titled "Molds, Mycotoxins and Related Contaminants in Water-Damaged Buildings."

Air Fresheners

Air fresheners are not "fresh." They are created using man-made chemicals. These products come in a variety of shapes and sizes including aerosols, plug-ins, candles, oils, incense sticks and commercial, metered air fresheners and deodorizers.

As stated in the article titled "Air Fresheners: The Dangers of Indoor Chemical Pollution:"

In no way, shape or form does a chemically-scented fragrance and/or aerosols propelled by butane, propane or other toxins create an indoor environment of fresh air.

In no way, shape or form does a chemically-scented fragrance and/or aerosol propelled by butane, propane or other toxins create an indoor environment of fresh air. Chemical "deodorizers" or chemical air "fresheners" only mask other odors. These products do absolutely nothing to improve the quality of indoor air, and in fact, can contribute to a host of ailments--from headaches, high pulse rate and nausea; to mention a few.²³⁷

Air fresheners have a negative effect on indoor air quality due to the chemicals used to create these products. Acetone, propane and butane are three of the most common ingredients in air fresheners. Acetone and propane are classified as cardiovascular or blood toxicants, gastrointestinal or liver toxicants, kidney toxicants, neurotoxicants, respiratory toxicants and a skin or sense organ toxicant. Butane is classified as a neurotoxicant which means that exposure can cause adverse effects on the central nervous system.

Phthalates are also used in air fresheners. (See our discussion earlier in this paper on the health effects of phthalates.) The U.S. Natural Resources Defense Council (NRDC) tested 14 common air fresheners. Even though none of those products listed phthalates as an ingredient, they found phthalates in 86% of the products. It is important to note that several of those products claimed to be all-natural or unscented.²³⁸

In a 2015 study, they discussed how the chemicals in air fresheners “react with ozone to produce secondary pollutants such as formaldehyde, secondary organic aerosol (SOA), oxidative product, and ultrafine particles.”²³⁹

These pollutants then adversely affect human health, in many ways such as damage to the central nervous system, alteration of hormone levels, etc. In particular, the ultrafine particles may induce severe adverse effects on diverse organs, including the pulmonary and cardiovascular systems.²³⁹

A 2017 paper by Steinemann, et al, looks at the science, health and policy perspectives relating to air fresheners. They also provide recommendations and research directions.

Exposure to air fresheners can prevent access for individuals in society and in the workplace. Also, businesses that use air fresheners may lose customers.

In addition to health risks, involuntary exposure to air fresheners can also prevent access for individuals in society and in the workplace. For example, the presence of an air freshener in a restroom can restrict an individual with asthma from accessing the restroom, if that individual experiences asthma attacks when exposed to air fresheners. Also, businesses that use air fresheners may lose customers, as recent studies indicate.²⁴⁰

Of the general population surveyed in the US, 17.5% are unable or reluctant to use the restrooms in a public place, because of the presence of an air freshener, deodorizer, or scented product. Also, 20.2% of the population reported that if they enter a business, and smell air fresheners or some fragranced product, they want to leave as quickly as possible.²⁴⁰

The biggest overuse of chemical air fresheners is in metered deodorizers that have resulted in hundreds of thousands of chemical spray dispensers being placed in hotels, department stores, retail outlets and workplaces throughout America.²⁴¹

Olfactory Fatigue

You should also be aware of olfactory fatigue (also known as odor adaptation) which results from a normal but temporary inability to pick up a particular smell after being exposed to it for a long time.²⁴²

The apparent strength or intensity of a fragrance is dependent on the length of time the fragrance is inhaled. This phenomenon is termed "odor adaptation" or "olfactory fatigue". Upon initial exposure to a fragrance, the perceived intensity is maximum. After several minutes of exposure, the perceived intensity is substantially reduced, due to diminished sensitivity of the fragrance-sensing olfactory receptor cells and higher brain olfactory centers. After several additional minutes, many people are not able to detect the fragrance on themselves, especially if it was applied in close proximity to the nose.²⁴²

When this happens in businesses using these commercial air fresheners, they (the management or employees) "turn up" the system. It often gets turned up beyond the limit recommended by the manufacturer which causes even greater harm to employees and customers.

This is a common problem in hotels and other businesses that use commercial air freshening systems. Sometimes they "crank it up" so high that you can even smell it in the parking lot, and it stays on your hair and clothes when you leave the building.

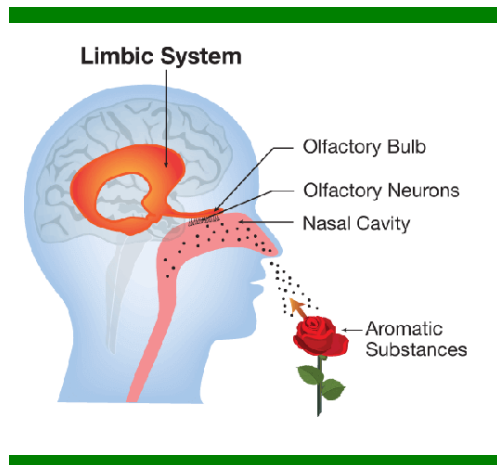
One easy solution is to implement fragrance-free policies. This would eliminate air fresheners, perfume, scented cleaning products and other sources of fragrances. On an interesting note, olfactory fatigue is also happening to people who use e-cigarettes.

We provide additional discussion and examples of fragrance-free policies in the next section on Fragrances.

Formaldehyde

Formaldehyde (FA) is a gas at room temperature. It chemically reacts with biological molecules, amino acids, nucleosides, nucleotides, DNA and proteins and forms DNA-protein crosslinks. Thus, it is recognized as a mutagen and a probable human carcinogen.

In June 2011, the U.S. Department of Health and Human Services added eight new substances, including formaldehyde, to its list of known human carcinogens.²⁴³



It is known to irritate mucous membranes and is released from paints, adhesives, sheetrock, ceiling tiles and wood materials. Formaldehyde has also been shown to have high sympathetic activity, increase the heart rate, alter the immune system, cause headaches, affect cognitive function, cause irritation and allergic contact dermatitis, stimulate reproductive problems and possibly cause birth defects. It can aggravate existing lung disease including asthma and emphysema.²⁴³⁻²⁴⁸

In research studies, FA showed effects on embryonic development and fetal organs (liver, lungs and kidneys). Mitochondrial damage was demonstrated in fetal tissues.²⁴⁹

Formaldehyde is toxic to humans and animals and was classified as a known carcinogen in 2011.

You can be exposed to FA in your home or workplace. Some of the sources of FA in the home are new construction materials (particle board, medium density fiber board, and plywood), surface finishes and a wide variety of consumer products.

Exposure in the workplace can occur in numerous industries, such as the manufacturing of formaldehyde and formaldehyde-based resins, woodworking and furniture making. Morticians, pathologists and laboratory workers are also commonly exposed to formaldehyde.

After Hurricanes Katrina and Rita, there were many news stories about people becoming ill in mobile homes that were supplied by FEMA (Federal Emergency Management Agency). Eventually, tests were done and high levels of formaldehyde were found.

Formaldehyde levels among all trailers in this study ranged from 3 parts per billion (ppb) to 590 ppb. While formaldehyde levels varied by trailer type, all types tested had some levels ≥ 100 ppb.²⁵⁰

From 2012 through 2014, there were numerous media reports about formaldehyde in laminate flooring sold by Lumber Liquidators. The flooring was purchased from China. Although the CDC concluded that the “concentrations may dissipate within several years,” researchers reviewed the data again in July 2016. The study concluded that non-cancer and cancer health effects are more than 12 times higher than those reported by the CDC and will persist for long periods of time (greater than 78 years).²⁵¹

Fragrances

Most fragrances and fragranced products are created with synthetic ingredients (i.e., not natural; made from chemicals).

Currently, there is a major loophole in federal law that allows companies to hide potentially hazardous chemicals in their products (under the guise of “trade secrets”), so most consumers are not aware they are being exposed to dangerous chemicals.

Dr. Anne Steinemann has done a great deal of work in regard to the chemicals used in fragrances and everyday products. She has conducted research, written several papers and given many presentations. The following excerpts provide a brief summary from one of her papers:

Society is suffused with fragranced consumer products: air fresheners, cleaning products, soaps, hand sanitizers, laundry supplies, and personal care products, to name a few out of hundreds. Fragranced products emit a range of volatile organic compounds (VOCs), such as terpenes (e.g., limonene), which often dominate pollutants found indoors and generate secondary pollutants such as formaldehyde.²⁵²



Despite numerous laws designed to protect human health and the environment, no law in the US requires the disclosure of all ingredients in fragranced consumer products. Protections on ingredient disclosure depend on the product. For all fragranced consumer products, the general term “fragrance” can be listed on the label, or a related term (such as “perfume”), rather than the specific ingredients in a fragrance. Yet an individual “fragrance” in a product is typically a complex mixture of several dozen to several hundred chemicals, primarily synthetic compounds.²⁵²

In two recent studies on the adverse effects of fragranced products, she found similar results for individuals in the United States and Australia.

A few of the statistics from these two studies are presented in this table.²⁵³

Adverse Effects of Fragranced Products		
	United States	Australia
% of total population that reported health problems when exposed to fragranced products	34.7%	33%
% not aware that fragranced products (even ones called green and organic) emitted hazardous air pollutants	67.3%	73.7%
% would not continue to use a product if they knew it emitted hazardous air pollutants	60.1%	56.3%
% reported health problems when exposed to air fresheners or deodorizers	20.4%	16.4%

% have lost work days or a job due to fragranced product exposure in the workplace	15.1%	7.7%
% of total population that cannot use toilets in public places due to air fresheners or deodorizers	17.5%	11.6%
% that would prefer that workplaces, health care facilities and professionals, hotels and airplanes were fragrance-free	53.2%	42.8%

Research is expanding in this area with several recent studies being published including a new study just released in July 2017. This new study looked at the prevalence and neurotoxicity of fragrance compounds belonging to the three most common groups: phthalates, synthetic musks and chemical sensitizers.²⁵³⁻²⁵⁵

Essential Oils

Essential oils are derived from plants (flowers, herbs and trees) and are used for various purposes. Although some studies have shown that essential oils have positive effects on mood and emotions, concerns have also been raised. Sourcing of these oils is one of the concerns, because some companies do not test their oils for quality.

Using undiluted essential oils on the skin can lead to dermatitis, blistering rash or complete and permanent loss of skin pigmentation. Sun sensitivity may also occur.

Another concern is the possibility of ingestion. Some companies advocate ingestion of these oils, but this can lead to burning of the esophagus.

One more risk is that some essential oils can interact with prescription drugs. For example, there is a long list of drug interactions for peppermint essential oil.

The most important advice from the experts is that essential oils should not be used on or around infants and children because they cannot fully metabolize the oils and liver damage has occurred in older children. Putting essential oils on the skin of infants and toddlers can cause breathing and nervous system disorders, seizures or even coma.

Even the National Association for Holistic Aromatherapy (NAHA) agrees with many of these concerns. They also state that placing any essential oil in the eye is extremely dangerous. This was primarily in response to claims that clary sage oil can be used to treat vision problems. The NAHA also points out there are several reports in the literature about the dangers of using Olbas oil in the eye or the nose. Olbas oil is the mixture of essential oils and menthol.²⁵⁶

Currently, essential oils are not regulated and research studies have primarily focused on the treatment of stress and anxiety and relieving certain symptoms in cancer patients (with mixed results). For example, one study showed that sniffing orange slices was more effective at

reducing nausea and coughing than inhaling an orange essential oil.^{257,258} Until further research is conducted, caution is advised.

U.S. Centers for Disease Control and Prevention (CDC)--Indoor Environmental Quality Policy

As stated in the Indoor Environmental Quality Policy implemented by the U.S. Centers for Disease Control and Prevention (CDC):⁹⁰

Fragrance is not appropriate for a professional work environment, and the use of some products with fragrance may be detrimental to the health of workers with chemical sensitivities, allergies, asthma and chronic headaches/migraines.

Additional information about the CDC's policy is provided as follows:

Scented or fragranced products are prohibited at all times in all interior space owned, rented, or leased by CDC. This includes the use of:

- Incense, candles, or reed diffusers
- Fragrance-emitting devices of any kind
- Wall-mounted devices, similar to fragrance-emitting devices, that operate automatically or by pushing a button to dispense deodorizers or disinfectants
- Potpourri
- Plug-in or spray air fresheners
- Urinal or toilet blocks
- Other fragranced deodorizer/re-odorizer products⁹⁰

Personal care products (e.g., colognes, perfumes, essential oils, scented skin and hair products) should not be applied at or near actual workstations, restrooms, or anywhere in CDC owned or leased buildings.

In addition, the CDC encourages employees to be as fragrance-free as possible when they arrive in the workplace.

To read the CDC's Indoor Environmental Quality Policy, go to our website.

Additional Information on Fragrance-Free Policies

Many businesses, universities, organizations and government agencies have adopted fragrance-free policies.

In North America, Canada has taken the lead on fragrance-free policies. Halifax is considered the “most scent-aware region” in North America. The Regional Municipality of Halifax, the provincial government, businesses, public transport, many performances spaces,

Fragrance is NOT appropriate for a professional work environment, and the use of some products with fragrance may be detrimental to the health of workers.

hospitals and educational institutions, and a number of public places and institutions have adopted voluntary scent-awareness policies.²⁵⁹

The University of Calgary, University of Toronto and McMaster University have established similar policies on their campuses.²⁵⁹

Here are a few additional examples in the U.S. and Canada:

- U.S. Access Board (federal government agency)
- Brigham & Women's Hospital
- University of Toronto (Canada)
- City of Portland, Oregon
- Department of Radiology, School of Medicine, Queen's University (Canada)
- Canadian Centre for Occupational Health & Safety (CCOHS): Scent-Free Policy for the Workplace (Canada)
- University of Missouri
- American Lung Association (sample fragrance-free policy)
- American Lung Association (sample fragrance-free policy for schools)
- HR and Employment Law News (sample wording for a fragrance-free policy)
- 36th District Court (busiest courthouse in Detroit, Michigan)



Links to each of these policies are posted on our website.

Additional Information on Fragrances in the Workplace

A related report on this topic titled “Fragrance in the Workplace: What Managers Need to Know” was published in the Journal of Management and Marketing Research. The report discusses relevant laws, court cases and legal liability for employers. It also provides recommendations for organizations that want to be proactive in promoting fragrance-free workplace policies.²⁶⁰

A study published in March 2017 concluded that fragrance use in the workplace is associated with work-related asthma. They reviewed the California Work-Related Asthma Prevention Program’s surveillance database and evaluated the data from 1993 to 2012. They

recommended several prevention methods including employee education, enforced fragrance-free policies, well-designed ventilation systems and good building maintenance.²⁶¹

For employers, it is important to know that allergies to fragrances or multiple chemical sensitivities are recognized as disabilities under the Americans with Disabilities Act (ADA). This was highlighted in the case of *McBride vs. City of Detroit*. In that case, the City of Detroit simply refused McBride's request and never attempted to provide a reasonable accommodation.²⁶²

According to the Job Accommodation Network (JAN), there are several ways that employers can provide accommodations to these workers.²⁶³

To sum it up, employers have a responsibility to provide safe working conditions for their employees. The CDC's Indoor Environmental Quality Policy is a tremendous step forward with the recognition that VOCs such as pesticides, cleaning products and even personal care products can harm the health of personnel. Guidelines such as these are as important in protecting the health of all workers and similar policies should be implemented in all buildings.

Household Products

People throughout the world are being exposed to chemicals in household products.²⁶⁴⁻²⁶⁹ One method being used to study these exposures is biomonitoring (i.e., measuring the concentrations of chemicals or their breakdown byproducts in people). Biomonitoring data also provide invaluable information to track exposure trends.^{266,267}

In 2009, Dr. Anne Steinemann conducted research to find the chemicals included in several household products. She found that all fragranced products tested (even those labeled as 100% organic, all natural or green) emitted toxic chemicals. They found more than 450 VOCs in 25 products. Only one VOC was listed on any product label, and only two VOCs were listed on any MSDS. More than 100 of those 450 VOCs are regulated in other sources but not in fragranced consumer products.²⁶⁸



In 2012, the Environmental Working Group presented a report titled "EWG Cleaners Database: Hall of Shame." Their findings were similar to the 2009 research conducted by Dr. Steinemann. The following information provides excerpts from their report:

Our research has turned up products loaded with extremely toxic compounds banned in some countries. Some of their ingredients are known to cause cancer, blindness, asthma and other serious conditions. Others are greenwashed, meaning that they are not, as their ad hype claims, environmentally benign. [Greenwashing refers to inaccurately labeling products as safe, non-toxic or green.] Still more hide the facts about their formulations behind vague terms like "fragrance."²⁶⁹

What should consumers do? Recommendations typically include avoiding products with any chemicals, fragrances, perfumes or scents, and avoiding all air fresheners and deodorizers. For cleaning, use white vinegar, baking soda, hydrogen peroxide or lemon juice.

Hydrogen Sulfide

Hydrogen sulfide (H₂S) is a colorless gas. At low concentrations, it has an obnoxious odor similar to rotten eggs. It is soluble in water. It is produced in nature primarily through the decomposition of organic matter by bacteria. It is a constituent of natural gas, petroleum, sulfur deposits, volcanic gases and sulfur springs.²⁷⁰⁻²⁷⁷

Hydrogen sulfide (H₂S), the gas with the odor of rotten eggs, was formally discovered in 1777, over 239 years ago. For many years, it was considered an environmental pollutant and a health concern only in occupational settings. Recently, however, it was discovered that H₂S is produced endogenously and plays critical physiological roles as a gasotransmitter. Although at low physiological concentrations it is physiologically beneficial, exposure to high concentrations of H₂S is known to cause brain damage, leading to neurodegeneration and long-term neurological sequelae or death. Neurological sequelae include motor, behavioral, and cognitive deficits, which are incapacitating.²⁷⁸



The U.S. Occupational Safety and Health Administration (OSHA) has regulations regarding the permissible concentrations of hydrogen sulfide, but they only pertain to healthy adult males in the workplace. These regulations do not apply to residential exposures and do not cover the more sensitive population, which includes the elderly, the very young and those with pre-existing illness.

Exposure can occur from various sources including ambient air near petroleum refineries, sewage treatment plants, sewers (sewer gas) and septic tanks. Sewer gas contains hydrogen sulfide and reduced sulfur compounds, such as methyl and dimethyl sulfide, ethyl and diethyl sulfide. These organo-sulfur compounds add to the toxicity of hydrogen sulfide in sewer gas.

Exposure to hydrogen sulfide occurs primarily by inhalation but can also occur by ingestion (contaminated food) and skin (water and air). Once taken into the body, it is rapidly distributed to various organs, including the central nervous system, lungs, liver, muscle, etc.

The health effects of hydrogen sulfide include acute system toxicity, central nervous system effects, irritation of eyes and lungs, nausea, dizziness, loss of balance, headaches, and shortness of breath. Studies have also shown that hydrogen sulfide affects the myelin sheaths in the brain. Here is an excerpt from one of those studies:

We studied ultrastructural and morphometric characteristics of nerve cells and myelinated fibers in the cerebral cortex after chronic exposure to natural gas containing hydrogen sulfide in low concentrations. Radioisotope assay revealed activation of protein synthesis in nerve cells after chronic exposure to natural hydrogen sulfide-containing gas in low concentrations (10 mg/m³ by H₂S) for 2 weeks. After 1 month the ultrastructure of myelinated fibers was characterized by sectorial loosening and demyelination.²⁷⁹

The most dangerous aspect of hydrogen sulfide results from olfactory accommodation or olfactory paralysis. This means that the individual can accommodate to the odor and is not able to detect the presence of the chemical after a short period of time. Death can occur.

Between 2004 and 2007, Chinese drywall was imported and used in thousands of homes in the United States. This change in the source of drywall was due a shortage of American-made drywall caused by the rebuilding efforts after numerous hurricanes during that time frame. Thousands of homeowners became ill, and tests were done. It was found that Chinese drywall emitted hydrogen sulfide and other toxic gases, and it was estimated to affect 100,000 homes in more than 20 states.^{280,281} Many lawsuits were filed. Large settlements were reached in some cases.

Since the Drywall Safety Act was passed in 2012, tainted drywall is no longer sold in the United States.

Conclusion

In this paper, we provided an overview of some of the common indoor contaminants that affect the air we breathe in our homes, schools and workplaces.

In the 2010 report by the World Health Organization (WHO) titled “Guidelines for Indoor Air Quality: Selected Pollutants”² they open with the following statement regarding the importance of good indoor air quality:

Clean air is a basic requirement of life. The quality of air inside homes, offices, schools, day care centres, public buildings, health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people’s well-being. Hazardous substances emitted from buildings, construction materials and indoor equipment or due to human activities indoors, such as combustion of fuels for cooking or heating, lead to a broad range of health problems and may even be fatal.²

It is staggering to comprehend the enormous impact on our global society as literally millions of individuals and families are harmed by contaminants inside our homes, schools and workplaces. The financial costs are equally staggering with estimates in the hundreds of billions of dollars.

Imagine how different things could be if the truth came to light and all vested parties worked together to improve our indoor air.

It is time we started to pay more attention to the indoor air we breathe. It is time for our national and world leaders to develop a comprehensive public health response to this devastating epidemic that has the potential to cripple our individual and collective futures.

We have highlighted the extensive research and look forward to collaborative efforts in this search for better health and safer living and working conditions.

Clean air is a basic requirement of life. The quality of air inside homes, offices, schools, day care centres, public buildings, health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people's well-being.

Global Indoor Health Network

The Global Indoor Health Network (GIHN) is a 501(c)(3) nonprofit organization dedicated to providing education and awareness of the health effects of mold and other indoor contaminants. We are uniting experts and laypersons from the world, with members throughout the United States and in eleven other countries. GIHN's vision is a global community of individuals and organizations working together to ensure that comprehensive information and guidance concerning medical treatment, investigative techniques and solutions are available to address the effects of contaminants in the indoor environment of homes, schools and businesses.

Visit our website at: <https://www.globalindoorhealthnetwork.com>.

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