THE STATE OF CHILDREN'S HEALTH AND ENVIRONMENT 2002

COMMON SENSE SOLUTIONS

FOR PARENTS AND POLICYMAKERS

by

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CHEC
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This research was funded by the Children's Health Environmental Coalition (CHEC) and the Colette Chuda Environmental Fund. CHEC was founded in 1992 by Nancy and James Chuda. CHEC's mission is to inform parents and all those concerned with the welfare of children about preventable health and development problems caused by exposures to toxic substances in homes, schools and communities, and to encourage the public to take action to protect children against these toxic threats.

Part 2. ASTHMA AND AIR QUALITY

Asthma is a chronic disease that constricts and inflames the airways, and the result is reduced airflow to the small sacs deep within the lung known as alveoli where oxygen is transferred to the blood stream and carbon dioxide is removed. The airways of asthmatics often become sensitive and responsive to diverse environmental contaminants. Although there is no single known cause of asthma, many substances are now recognized for their potential to initiate an episode or make it more severe.[1]

Costs associated with asthma include direct medical costs, missed days of school for children, missed days of work for parents, and potential for diminished academic performance due school absence. The illness is now the primary reason for school absenteeism in the U.S., and the social and psychological effects of missed school have not been well studied.

Asthma Prevalence

The Centers for Disease Control and Prevention (CDC) estimates that nearly 5 million children between the ages 0-18 have asthma in the U.S. –about 7% of all children in the nation.[2] Prevalence rates for children increased 74% between 1980 and 1995,[3] and the number of children dying from asthma increased threefold between 1979 and 1996.[4] Rates have increased for all ages, and in most regions of the nation. Prevalence rates have increased too quickly over the past several decades for genetic factors to provide a sufficient explanation. Genetic traits may play an important role in affecting underlying susceptibility. These trends most likely reflect differences in exposure to chemical, physical and biological substances in children's environments.[5]

Asthma prevalence rates are not yet tracked in most U.S. schools. A survey of asthma prevalence in Connecticut schools by Environment and Human Health, Inc. demonstrated that among 513,000 children who attended Connecticut public schools in 2000, on average 1 in 11, or 8.7%, had asthma. For individual schools, rates ranged between 3 and 20%.[6]

Figure 3

Trends in Prevalence of Asthma Among Children[7]

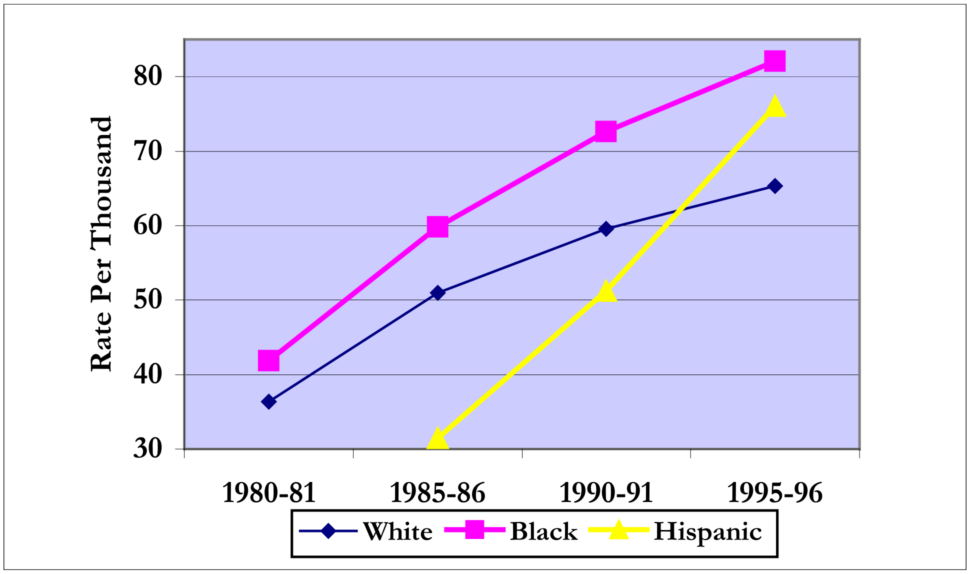


Figure 3 demonstrates trends in prevalence by ethnicity. Some ethnic populations experience higher prevalence and severity of asthma than others. Those with low socioeconomic status are disproportionately represented in the trends of increasing asthma prevalence.[8] The prevalence of asthma is greatest among African American children but the incidence of childhood asthma appears to be increasing the most rapidly among Latinos.[9] Latinos and African Americans are more likely than whites to live in areas that exceed federal standards for many toxic pollutants such as lead, ozone, carbon monoxide, and particulates.[10] [11] [12] Children in urban environments have the highest asthma rates[13] [14] and the illness is a primary cause of childhood hospitalization in cities.[15] [16]

Children may be more susceptible to asthma than adults; some children are more susceptible than others, and any individual's sensitivity may change over time. Full maturity of the human respiratory system does not occur until approximately 18-20 years in age. Children are often more exposed to environmental hazards than adults. Children breathe nearly twice the amount of air inhaled by adults when adjusted for bodyweight. This means that children will be more highly exposed to any air contaminants than adults.[17] Young children spend more time indoors than older children, as much as 85% of each day on average, and therefore may be more exposed to indoor contaminants than outdoor pollution.[18]

Causes and Triggers of Asthma

Certain environmental conditions are known to trigger episodes of asthma, increase their severity, or prolong their duration. Asthma prevalence has been associated with infectious diseases, allergens, socioeconomic status, psychological factors, low birth weight, drug abuse, and genetic characteristics. Some biological agents such as molds and pollen are not known to cause asthma, but may increase prevalence, severity, or episode duration.[19]

Low birth weight may also increase the risk of asthma in children. In one study, prevalence of asthma was 6.7% in children weighing at least 2,500 grams at birth and nearly 22% in children with a birth weight less than 1,500 grams.[20] Pregnant women may reduce the chances of a low birth weight baby through proper nutrition and vitamin intake, and avoidance of tobacco, alcohol and illicit drugs.

Costs of Asthma

CDC estimated that the cost of asthma in the U.S. exceeded $14 billion in 2000. The Asthma and Allergy Foundation of American estimated that the 1994 costs were approximately $10.7 billion. Children with asthma incurred 88% higher health care costs per year on average than asthma-free children ($1,060 vs. $563). Asthmatic children required 2.7 times the prescription drugs, and experienced twice as many in-patient care days and 65% more non-urgent medical care visits when compared to asthma free children.[21] The estimated annual cost of treating asthma in children under-18 years of age is $3.2 billion.[22]

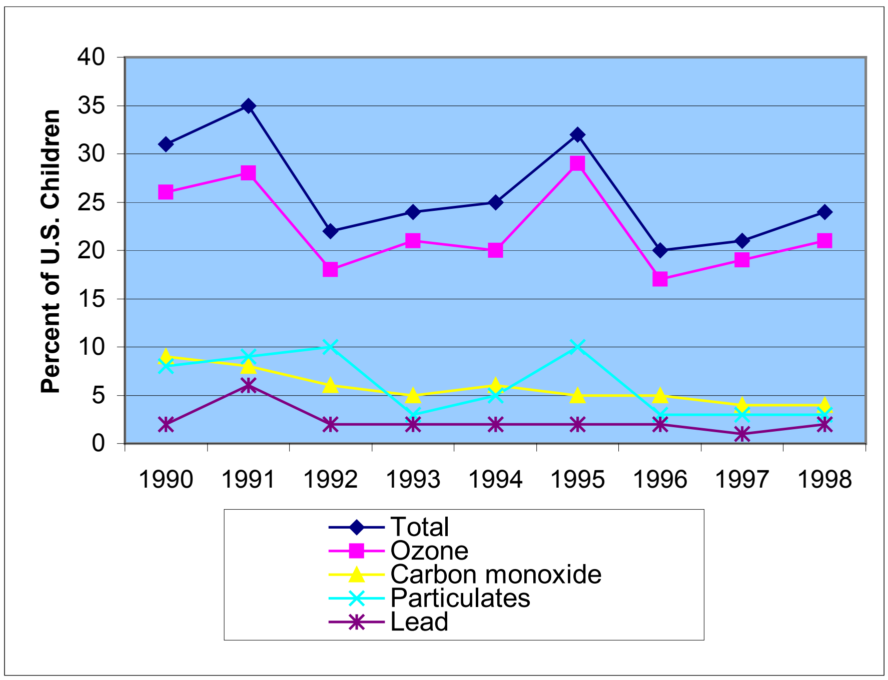
Outdoor Air Pollution

Outdoor air pollution has been associated with asthma by many scientists, and may help to explain its increasing incidence and severity of asthma.[23] [24] [25] [26] High exposure to nitrogen dioxide, particulate matter, sulfur dioxide, and ozone can adversely affect lung function in asthmatics.[27] [28] [29] [30] [31] Short term exposure to air pollution has been associated with an increase in respiratory symptoms in numerous studies.[32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42]

EPA estimated that the probability that children with asthma will have an attack is 40% higher on high outdoor pollution days.[43] One recent study found that when children moved residences to areas with lower PM_{10} levels, their rates of lung function growth increased. Those that moved to more polluted areas experienced declines in lung function growth.[44]

Many live in parts of the country where outdoor pollution exceeds federal standards. In 1998, EPA estimated that 25% of all U.S. children lived in parts of the U.S. that did not meet at least one of the federal limits for air quality,[45] and one study found that severe asthma was more common within these areas.[46] The percentage of the population living in areas not attaining air quality standards for ozone is 52% for whites, 62% for African Americans, and 71% for Latinos. This disparity is similar for a variety of other air pollutants.[47] The uneven distribution of air pollution may be contributing to some of the increased rates of respiratory disease found especially among minority and poor children.[48]

Figure 4: Children Living In Areas Not Meeting Federal Minimum Air Quality Standards[49]



Does this offer reassurance for those who live in areas where pollution is less than federal limits? The answer is clearly no since many hazardous chemicals are neither listed nor monitored by government regulators. And the number of people living in areas beyond compliance is projected by EPA to increase, when sufficient data will become available to judge compliance with tougher $PM_{2.5}$ standards (3 years of data are not yet available).

Diesel Exhaust

Diesel exhaust is a complex mixture of toxic chemicals, including benzene, 1,3-butadiene, and soot, all classified as known human carcinogens by the U.S. National Toxicology Program. It also includes several dozen additional chemicals classified as toxic or hazardous air pollutants.[50]

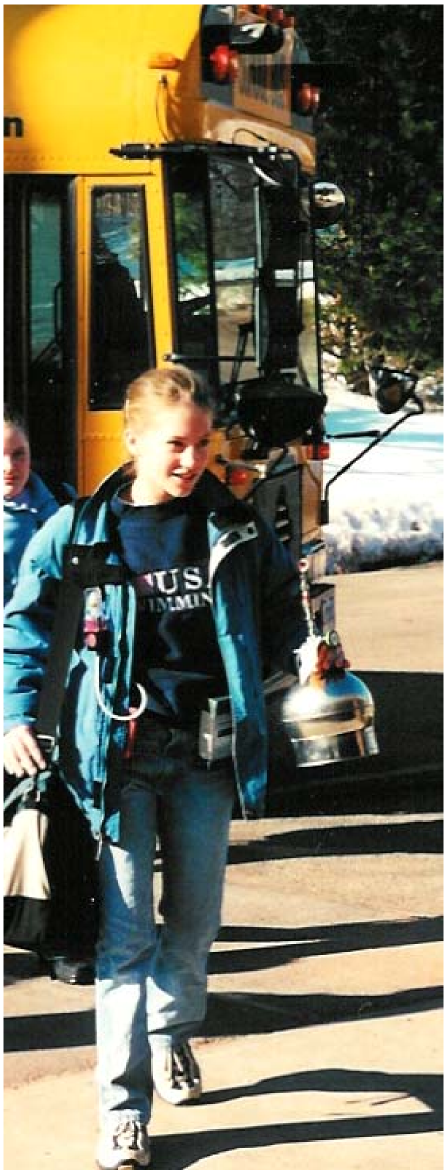


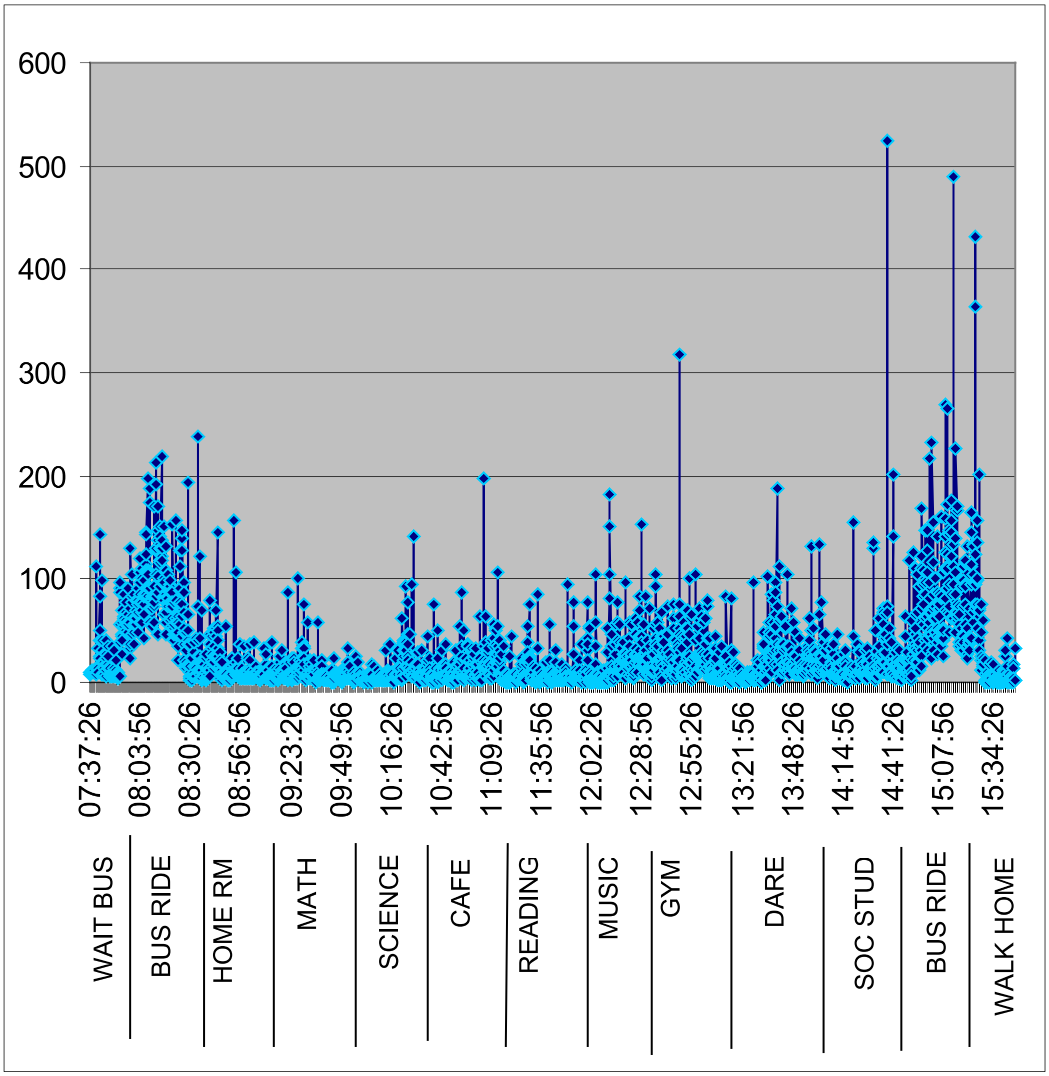
Photo: Wargo

In December of 2000, EPA announced new standards that will apply to diesel engines and fuels. These will be phased in between 2006 and 2010. In justifying the tougher standards, the Agency stated:

"EPA has determined that diesel exhaust is likely to cause lung cancer in humans…As a result, today's action will prevent 8,300 premature deaths, 5,500 cases of chronic bronchitis, and 17,600 cases of acute bronchitis in children. It will also avoid over 360,000 asthma attacks and more than 386,000 cases of respiratory symptoms in asthmatic children annually. The action will prevent 1.5 million lost work days, 7,100 hospital admissions and 2,400 emergency room visits for asthma every year."[51]

In a recent study of childhood exposure to air pollution by Environment and Human Health, Inc. students carried or wore air monitoring equipment while they moved through their school days. In contrast, EPA and state officials normally collect air quality data from fixed monitors. Nearly 24 million children ride 600,000 school buses each school day in the U.S. If children spend an average of 1 hour per day on the bus, this amounts to 180 hours per year of transit time. Most buses are powered by diesel fuel.[52]

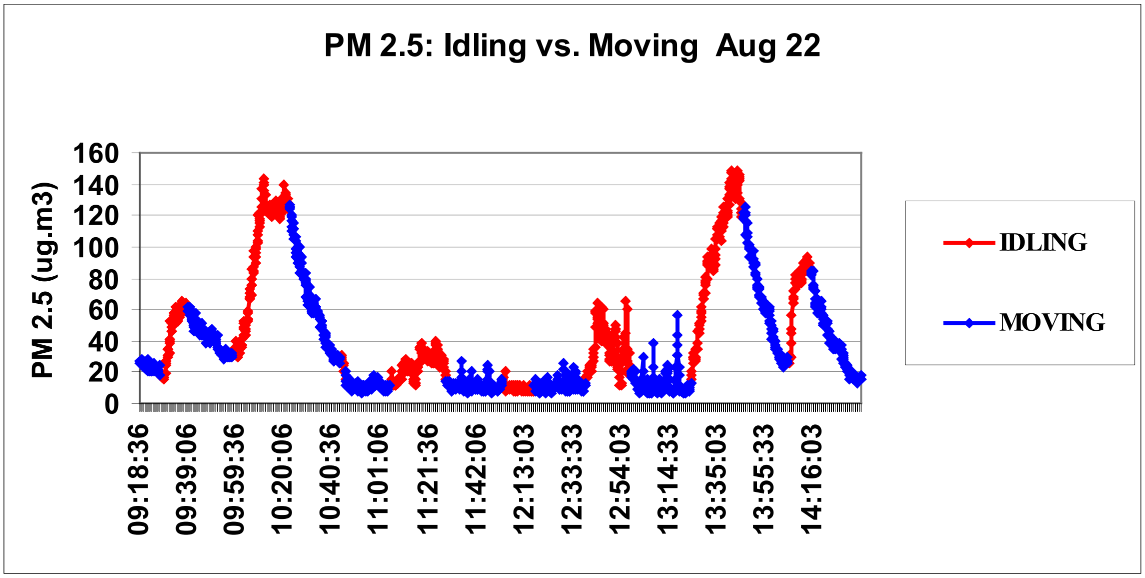
Figure 5
Student Exposure to PM_{10} During School Day



Source: Environment and Human Health, Inc. 2002.

Figure 5 demonstrates that at the beginning of the day particle levels were similar to background readings. This was quickly followed by a burst of pollution surrounding the bus ride to school. The bus ride home at the end of the day demonstrates a second high intensity period of pollution within the bus.

Figure 6
Particles in Idling vs. Moving Buses



Source: Environment and Human Health, Inc. 2002.

Figure 5 demonstrates that idling buses tended to accumulate $PM_{2.5}$, and these levels diminished via ventilation when buses began moving. This finding clearly suggests strict limitation of bus idling as a strategy to reduce children's exposure to diesel exhaust, especially among queued buses.

Queued and Idling Buses

Photo: Wargo

Ozone

Asthma-related emergency room visits for children increased as ozone increased in a number of studies.[53] [54] [55] [56] [57] [58] Young children are particularly sensitive to ozone levels.[59]

Figure 7: Ozone Non-Attainment Areas 1999[60]

Atlanta	Serious	Milwaukee	Severe
Philadelphia	Severe	NY-NJ-CT	Severe
Baltimore	Severe	Sacramento	Severe
Baton Rouge	Serious	San Diego	Serious
Boston	Serious	San Joaquin	Serious
Chicago	Serious	Santa Barbara	Serious
Dallas	Serious	SE Desert CA	Severe
El Paso	Serious	Springfield	Serious
Greater CT	Serious	Ventura CA	Severe
Houston	Severe	Wash DC	Serious

Particulate Matter (PM)

Airborne particles, or particulate matter, can aggravate asthma.[61] Particles less than 2.5 micrometers in diameter result from all types of combustion (such as motor vehicles, power plants, and wood burning) and some industrial processes, and these are most closely associated with such health effects as increased hospital admissions and emergency room visits for heart and lung disease, increased respiratory symptoms and disease, decreased lung function, and premature death.[62] [63]

Sulfur Dioxide

Sulfur dioxide is produced during the burning of sulfur-containing fuels. Major sources include power plants and industrial boilers. High sulfur dioxide concentrations have been associated with asthma attacks and deaths due to asthma in the general population.[64] At very high levels, sulfur dioxide may cause wheezing, chest tightness, and shortness of breath in people who do not have asthma.[65] Exercising asthmatics exposed to sulfur dioxide develop airway constriction within minutes, even at levels of 0.25 ppm.[66] The sulfur dioxide resulting from fireworks may exacerbate asthma in asthmatic children.[67]

Nitrogen Dioxide

Nitrogen dioxide can cause respiratory symptoms such as coughing, wheezing, and shortness of breath in children with asthma. Even short exposures to nitrogen dioxide can affect lung function. Animal studies suggest that long-term exposure to nitrogen dioxide may increase susceptibility to respiratory infections and may cause permanent structural changes in the lungs.[68] Several studies have linked nitrogen dioxide with increased hospital admissions for asthma in children.[69 70] Major sources of nitrogen dioxide include automobiles and power plants. It reacts with volatile organic compounds (VOC's) resulting in the formation of ground-level ozone.

Air Quality In High Traffic Areas And Within Vehicles

Some of the most hazardous air that children breathe outdoors may occur within vehicles. Nearly 300 billion gallons of gasoline and diesel fuel are consumed each year in the U.S.[71] Children living near intense traffic are more likely than those residing near light traffic to require more medical care per year for asthma[72] and they reported a higher prevalence of most respiratory symptoms.[73 74]

The California Air Resources Board (CARB) studied air contaminants within cars in 1998. Levels of hazardous air pollutants including benzene and formaldehyde, among other chemicals were 2-10 times higher than levels detected at outdoor monitoring facilities. The International Center for Technology Assessment also reported that within-vehicle air pollutants were often lower along highways than within vehicles.[75] A European study of air pollution recently published in Lancet estimated that traffic related air pollution was responsible for nearly ½ million asthma attacks.[76]

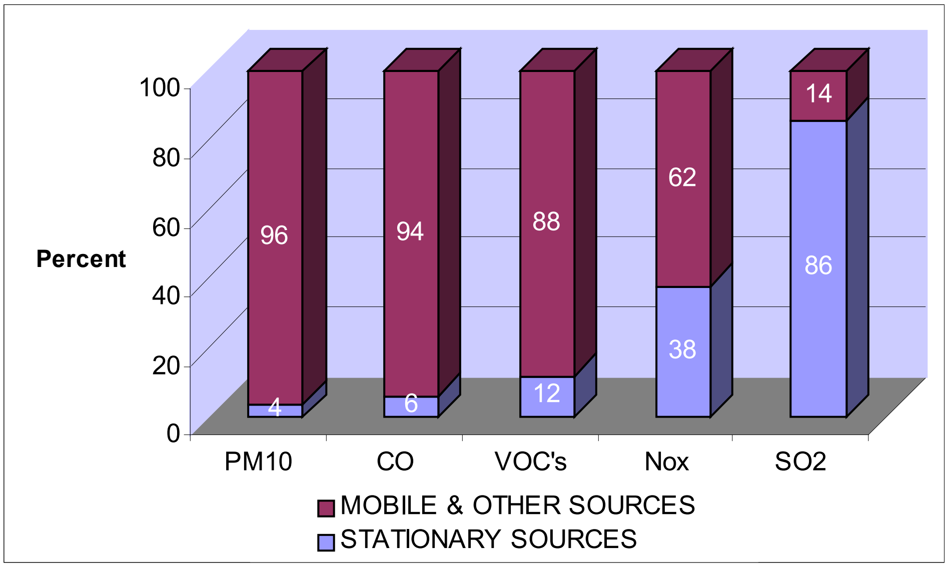
Hazardous Air Pollutants (HAPs)

Nearly 189 Hazardous Air Pollutants regulated by EPA include chemicals that may cause cancer, birth defects, neurological disorders, or respiratory disease.[77] Relatively little is known about the health risks for HAPs exposures found in outdoor air and less is known about the effects of HAPs on asthmatics. About 70% of HAPs are VOCs, chemicals that vaporize quickly when exposed to air.

The contribution of the 20,000 major sources to national air pollution is represented in Figure 8, below. These data demonstrate that mobile and other minor sources are very important contributors to the national air quality, including VOC gases.

Figure 8

Sources of National Air Pollution In 1998[78]



Indoor Air Quality

Indoor air may often be more polluted than outdoor air. Children spend more time indoors than outdoors and may be exposed to a variety of asthma triggers inside their home or at school.[79] Contributors to poor residential indoor air quality include cleaning products and pesticides used inside the home, formaldehyde off-gassing from pressed-wood furniture, tobacco smoke, commercial products including paints, cleaning agents, pesticides, and perfumes; components of building structures (sealants, plastics, adhesives, and insulation materials); animal and insect allergens; and molds and household gas appliances.

Tighter, more energy efficient structures may have one-tenth the air exchange rates of older structures with windows, doors and walls that are less well-sealed. Windows that do not open, and heating/cooling systems that recycle rather than exchange air, may exacerbate both chemical and biological asthma triggers. Poor wall ventilation can cause a build up of moisture as temperature and humidity change, providing an ideal damp and dark environment for the growth of mold and fungi.

Biological Pollutants

Indoor biological pollutants may pose a serious threat to the health of children. These include animal and bird dander, dust mites and cockroach residues, fungi, infectious agents (bacteria or viruses), and pollen. Molds of certain species may produce highly toxic substances known as mycotoxins including the species *Fusarium, Trichoderma,* and *Stachybotrys.*[80] [81]

Humidity levels above 50% favor the growth of molds that may impair respiratory function. Conditions necessary to support biological growth (nutrients and moisture) are found in many locations, such as bathrooms, damp or flooded basements, wet appliances (such as humidifiers, washing machines, dishwashers). Carpeting in humid environments will trap moisture, and provide an excellent breeding environment for mold and fungi. Leaking roofs and poor drainage also contribute to the growth of mold and fungi. Humidifiers, poorly vented heaters, and air conditioners increase the chances that moisture will form on interior surfaces. EPA estimates that 30-50% of all structures in the U.S. and Canada have damp conditions, favoring the growth and buildup of biological pollutants. Structures built in former wetlands, floodplains, coastal communities or other areas with high groundwater tables are more likely to have biological health threats than those sited in well drained areas. Dense foliage and shrubbery immediately adjacent to structures will reduce air movement and contribute to moisture buildup.

Nitrogen Dioxide

High levels of nitrogen dioxide can cause lung injury and a decrease in pulmonary defense mechanisms due to the oxidant effects of the gas.[82] Daily personal exposures to nitrogen dioxide have been associated with asthmatic symptoms.[83] Emissions from gas stoves have been associated with respiratory symptoms and reduced lung function in both healthy and asthmatic children.[84] [85] [86] [87] Nitrogen dioxide is produced during combustion processes, and indoor sources include gas stoves, gas heaters, and smoking. In the home, natural gas-fueled home appliances, if not properly vented and used, are the most common potential source of indoor nitrogen dioxide.

Environmental Tobacco Smoke

ETS contains several hundred recognized toxic substances, including numerous carcinogens. Tobacco smoke increases the severity of asthma and childhood exposure to tobacco smoke may cause asthma.[88] Nearly 48 million Americans smoke tobacco products, 4.5 million are children between the ages of 11-17.[89] Every day, nearly 2,000 children less than 18 become daily cigarette smokers.[90] In 1996, almost half of all children aged two months to 11 years lived in a home with at least one smoker.[91]

Children living in households with smokers have a higher risk of asthma, bronchitis, ear infections, and pneumonia.[92] Intensity of maternal cigarette smoking is associated with childhood asthma prevalence. In one study, heavy maternal smoking more than doubled the chance of having an asthmatic child. Smoking by the maternal caregiver is also associated with clinically significant asthma in children.[93] Exposure to ETS during childhood and *in utero* exposure to maternal smoking are associated with adverse effects on lung growth and development.[94] Childhood exposure to ETS is associated with an increase in asthma attacks per child, earlier symptom onset, an increase in medication use, and prolonged recovery from attacks.[95] The lowest asthma rates are found in children of parents who do not smoke.[96]

Volatile Organic Compounds

VOC levels are normally higher indoors than outdoors.[97] In 1989, EPA identified more than 900 volatile organic compounds in indoor air.[98] These chemicals are found in building materials, paints, furnishings, adhesives, cleaning agents, solvents, perfumes, cosmetics, clothes that are dry cleaned, tobacco smoke, fuels, and other combustion by-products including auto and diesel exhaust. In 2000, the U.S. National Academies of Science (IOM) concluded: "…indoor VOC's and formaldehyde may cause asthma-like symptoms."[99] Little is known about the variability of VOC exposures experienced by children or adults indoors.[100]

Formaldehyde

Formaldehyde causes cancer in laboratory animals and may cause cancer in humans. Individuals have developed allergic reactions to formaldehyde through skin contact with solutions of formaldehyde or durable-press clothing containing formaldehyde. Others have developed asthmatic reactions from exposure to formaldehyde.[101] The chemical may produce nasal and bronchial irritation and congestion.

Significantly greater prevalence rates of asthma and chronic bronchitis were found in children from houses with higher formaldehyde levels than in those less exposed, especially in children also exposed to ETS.[102] [103] In a study of mobile homes and homes with particle board flooring, formaldehyde was also found to be associated with increased severity of dry and sore throats, blood nose, sinus irritation, sinus infection, cough, headache, chest pain and other health symptoms.[104]

The primary sources of formaldehyde in the homes of non-smokers are insulation and construction materials, chipboard, plywood, water-based paints, fabrics, cleaning agents and disinfectants.[105] Cigarette smoke, vehicle exhaust and poorly ventilated heating systems are additional sources of formaldehyde.

Paints

Paints are commonly composed of pigments, fungicides, and solvents, and some include benzene, a known human carcinogen. A significant increase in formaldehyde concentration has been noted in dwellings with newly painted wood details. Exposure to chemical emissions from indoor paint is related to asthma, and some VOCs may cause inflammatory reactions in the airways.[106] Asthmatics have reported a significant increase in "breathlessness" while using conventional paint.[107] VOC-free paints may irritate asthmatics less than water and oil based paints containing VOC's.

Fragrances

Fragrances often contain VOC's that may increase the prevalence and severity of asthma among sensitive individuals. Many strong-smelling agents such as perfumes, paints, cosmetic sprays, pesticides, and scented cleaning solution have been reported to induce acute asthma episodes.[108] In one study, 90% of a group of 60 asthmatics surveyed reported exacerbations of asthma in relationship to exposure to odors, and nearly 40% had visited emergency rooms after these incidents.[109] The chemical content of fragrances is not required to be labeled in the U.S.

School Air Quality

Children spend more time in schools than any other indoor environment, other than their homes.[110] Respiratory health of school children may be harmed by poor indoor air quality that may become contaminated by numerous agents, including: molds and fungi from moisture, cleaning agents, building renovation debris, paints, waxes and wood finishes, fragrances and solvents in cleansers, classroom pet dander, pesticides applied indoors and outdoors, unvented stoves, vapors from laboratory chemicals, vapors from photo and art supplies, emissions from motor vehicles and school buses, and emissions from nearby land uses such as industrial facilities, agricultural lands or transportation corridors.

Law and Policy Governing Air Pollution in the U.S.

- Air quality law in the U.S. is structured to limit outdoor pollutants in three main categories: "Primary or Criteria Pollutants", "Hazardous Air Pollutants", and "Mobile Source Emissions". Primary pollutants include particulate matter, carbon monoxide, ozone, sulfur dioxide, lead and nitrogen oxides. Hazardous air pollutants are similarly listed in the law and include nearly 189 compounds. Mobile source rules apply to gas and diesel powered vehicles.

- Outdoor air pollution measurements are normally collected from fixed monitoring facilities, and then averaged by the government, and this practice is allowed by federal law. Fine particulate matter ($PM_{2.5}$ for example) is averaged daily, and again over 3 years. Sensitive asthmatics may experience airway constriction following exposures that are far shorter than these averaging periods.

- The Toxic Release Inventory (TRI) requires the reporting of nearly 600 toxic substances to the air, required by the Emergency Planning and Community Right-to-know Act (EPCRA, 1986) and the Pollution Prevention Act (PPA, 1990). [111] TRI demonstrates a declining trend of some major types of chemicals from stationary sources, and this is well publicized by EPA as evidence that our pollution laws are working. However, national databases now cover only a small percentage of pollution released to the environment—as little as 5% by one recent estimate.[112] Tens of thousands of smaller polluters are not monitored. Ninety-six percent of emissions from large industrial sources are estimated by the polluters themselves, using indirect "emissions factors" rather than direct measures. These factors have been found by EPA to be "less than average in quality" as indicators of real emissions.[113]

- Fuel economy has increased only slightly over the past several decades, while numbers of vehicles and miles traveled have both increased, and regulations governing vehicle fuel efficiency standards have changed little since 1982. One combined effect of these trends is that ground level ozone remains a significant respiratory health threat for millions of Americans, especially in California and Northeastern states.

- The nation's monitoring system for air quality is incapable of detecting the variability in pollution that most children experience daily as they move between indoor and outdoor environments, i.e. from homes, vehicles, schools, play areas, shopping centers, and other indoor settings. Connecticut, for example, has only 13 fixed sites that monitor PM_{25}, and only 4 of these take daily readings. Personal monitoring of exposure to air pollutants has in some cases demonstrated little relation between fixed monitor sampling and the daily exposures of children as they move through their normal routines.

- Within-vehicle air quality remains unregulated in the U.S., with the exception of tobacco products in public vehicles, such as buses, trains and aircraft, and certain restrictions on applications of pesticides.

- Indoor air quality is not often regulated in the U.S. Some chemicals are restricted in some occupational settings, tobacco products are limited from use in some occupational settings, and some pesticides are prohibited to be used indoors. EPA could further regulate indoor air quality under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Thousands of pesticide products are allowed by EPA to be used indoors—even in schools while children are in classrooms.

- The Energy Policy and Conservation Act (1974) encouraged building standards to promote energy efficiency, and to reduce the exchange of indoor and outside air.[114] Many older homes have air exchange rates of 2 times per hour, while new energy efficient offices and homes may have a rates 10 times lower.[115]

- EPA has the authority to regulate consumer products that could introduce hazardous air pollutants indoors under the Toxic Substance Control Act (TSCA). The Agency has the authority to require chemical testing, record keeping, and prevent the use of products it finds to be inherently dangerous. EPA also has broad authority under TSCA to require advance warning for consumers of dangerous chemicals, discretion that it has chosen to exercise rarely. And the law provides chemical producers with ample opportunity to contest regulations, and to protect product contents as private intellectual property.[116 117]

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Note: References in Parts 2-6 may refer to previous citations listed at the end of earlier parts.

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