OUTDOOR AIR QUALITY

QUICK FACTS

Air is the only natural resource to which everyone is exposed throughout their entire lives.

National air quality has improved since the early 1990s, but air quality problems remain and present many challenges in protecting public health and the environment.[1,2]

National air quality data are limited because sampling is not comprehensive and varies widely in the frequency and the locations of sampling and the types of pollutants monitored at each of those locations.[3]

More than 142.2 million people in the U.S. still live in counties that have unhealthy levels of urban air pollution.[1,2]

INTRODUCTION

National air quality has improved since the early 1990s. Trends in outdoor concentrations of all six commonly monitored air pollutants have declined over time with carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead experiencing dramatic reductions during the last several decades. Despite these successes, air pollution in the United States continues to pose a public health threat that potentially affects millions of individuals. Two principal pollutants that show less dramatic declines over time—ozone and particulate matter—are associated with numerous adverse health outcomes, including increased hospitalization rates for respiratory and cardiovascular problems. Today, 42 % of the U.S. population still lives in counties where ozone or particle pollution levels are unhealthy.[1]

The picture for exposure of the U.S. population to other air pollutants known as air toxics, or hazardous air pollutants (HAPs), is much less clear. These pollutants might cause cancer, reproductive effects, and other significant health or ecological effects. Of the 187 hazardous air pollutants that are regularly tracked through emission inventories rather than air monitoring, benzene is the most widely tracked and is known as the national driver of cancer risk. Millions of people live in areas where hazardous air pollutants are estimated to be at levels that may pose potential health concerns.[4]

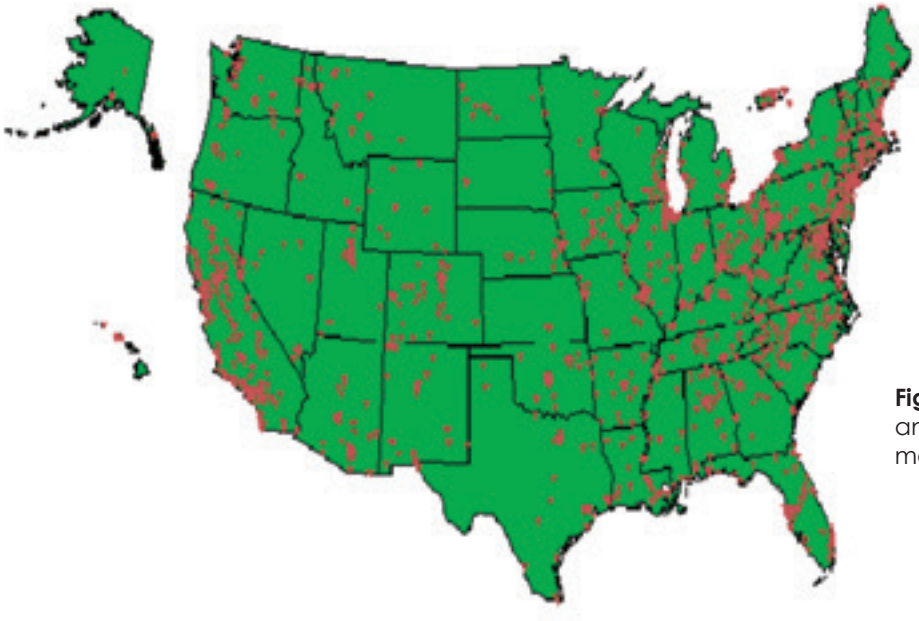


Figure 1. Roughly 4,000 state and local monitoring sites exist measuring outdoor air pollution.[3]

TRACKING OUTDOOR AIR POLLUTION

Currently, the air quality of the entire United States is based on measurements taken at some 4,000 outdoor monitoring sites operated by state and local authorities (Figure 1).[3] While the purposes for sampling vary by location, many sites evaluate state or local compliance with federal air pollution standards, which regulate six primary pollutants considered harmful to the public's health and the environment:

- Ozone
- Particulate matter
- Carbon monoxide
- Lead
- Nitrogen dioxide
- Sulfur dioxide

Monitoring of these six primary pollutants differs by site, with some measuring only a single air pollutant and others measuring multiple pollutants. Monitoring may be continuous, daily, weekly, or several times a month. Little or no monitoring may be conducted for the 187 air pollutants classified as hazardous air pollutants (HAPs). In the absence of monitoring, estimating population exposures requires computer modeling of HAPs and emissions data supplied by local and state sources.[3]

Many public health professionals recommend supplementing this existing air monitoring network to gather more data. For example, additional sampling could track average population exposures to air pollutants which, when analyzed with health outcome data on asthma, heart attack, stroke, and other cardiovascular and respiratory diseases, would yield new or more complete information about environmental health trends. These additional data could also help to strengthen current findings.

WHAT IS OZONE?

Ozone (O_3) is a colorless gas that occurs naturally approximately 10 to 30 miles above the earth's surface in the stratosphere. This "good ozone" forms a layer that protects the Earth from the sun's ultraviolet (UV) rays. In contrast, ground-level ozone, often labeled "bad ozone," is the primary component of smog and can adversely affect health and damage the environment. Ground level ozone is produced during a chemical reaction involving nitrogen oxides and volatile organic compounds (VOCs) in the atmosphere. Significant sources of VOCs are chemical plants, gasoline pumps, oil-based paints, auto body shops, and print shops. Nitrogen oxides result primarily from high temperature combustion. Significant sources are power plants, industrial furnaces and boilers, and automobiles. Strong UV radiation from the sun and warm air temperatures drive the reaction that produces high levels of ozone, which is why we see higher levels in summer months compared to winter months.

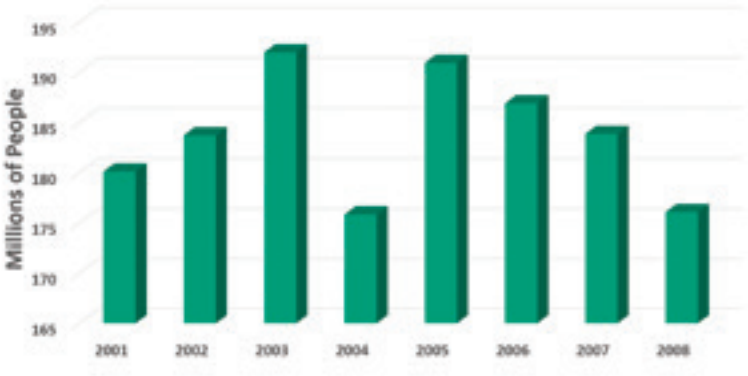


Figure 2. Number of people (in millions) living in counties where ozone monitoring measurements were greater than the NAAQS 2001-2008[21]

HEALTH EFFECTS OF OZONE

One of the earliest notations about the relationship between air quality and health is attributed to Hippocrates, writing in 400 B.C.E.[5] Since then, the link between the air and many aspects of health has been well documented in thousands of studies.

Breathing in ozone is not healthy, and increased outdoor activity, such as among athletes, allows ozone to penetrate deeper into the lungs, into areas more readily injured.[6,7] Ozone can damage cells that line the lungs and has been shown to affect children's lung development.[8] Repeated damage to these cells can lead to long-term health effects.

Short-term exposures to ozone have been associated with an increase in cardiovascular and respiratory hospitalizations and deaths.[9] Some data suggest that excess disease and death occurs even at ozone concentrations below the current U.S. national standard.[10,11] Ozone also is associated with such adverse health effects as

- Lung and throat irritation
- Lung inflammation
- Chest pain
- Wheezing
- Coughing
- Difficulty breathing
- Aggravated bronchitis, emphysema, and asthma symptoms[12,13,14,15]

People vary widely in their vulnerability to the toxic effects of ozone. Populations at risk are those who typically spend long periods of time outdoors as well as other sensitive groups.[6,16,17,18,19] Specifically, the following people can be at higher risk:

- Infants
- Children
- Adults who work outdoors
- Athletes of all ages
- The elderly
- People with respiratory disease, including asthma
- People with cardiovascular disease

WHAT ARE THE STATUS AND STAUS STATUS AND TRENDS FOR OZONE

From 1990–2012, measured levels of ground level ozone concentrations have declined nationally by 14%. During the 1990s, levels remained more or less steady and then began a notable decline after 2004.[20] The ozone reductions stem from decreasing levels of summer emissions of nitrogen oxides and VOCs from transportation and fuel combustion.

From 2001–2008, about 22% (676 of the 3141) of U.S. counties collected sufficient ozone monitoring data to generate estimates of exposure that take into account the size of the county population and the number of days that ozone levels exceeded the National Ambient Air Quality Standards (NAAQS). Figure 2 shows the number of people living in counties where measured ozone concentrations exceeded the NAAQS from 2001–2008.

Nationally, the trend in ozone exposure is declining, although there are areas of our country where ozone levels are unhealthy for many days of the year.[20]

In addition to measuring ozone concentrations, new studies integrate weather information and patterns of ozone concentrations to gain a better understanding of ozone levels, including trends, at an even more refined geographical scale. Such information offers insights that will aid in developing ways to further reduce ozone concentrations and individuals' exposures to ozone.

WHAT IS PARTICULATE MATTER?

Air pollution that takes the form of particles or droplets suspended in the air is called particulate matter (PM). Particulate matter differs in many ways from other gaseous air pollutants, such as ozone, because it varies widely in size and composition and can include acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust.

The sources of particulate matter vary based on location, season, and whether they are from primary or secondary sources. Primary sources emit particulate matter directly, whereas secondary sources emit gases that react or combine in the atmosphere to form particulate matter. For example, forest fires, road dust, electrical power plants, industrial processes, and cars and trucks are primary sources (Figure 3). Elemental and organic carbon, sulfates, nitrates, and metals are primary constituents of particulate matter.

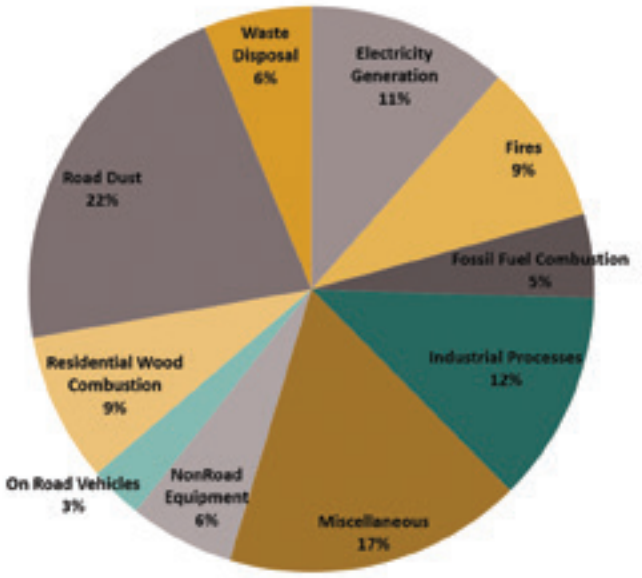


Figure 3. Primary Fine Particulate Matter Emissions in the United States by Source, 2005[22]

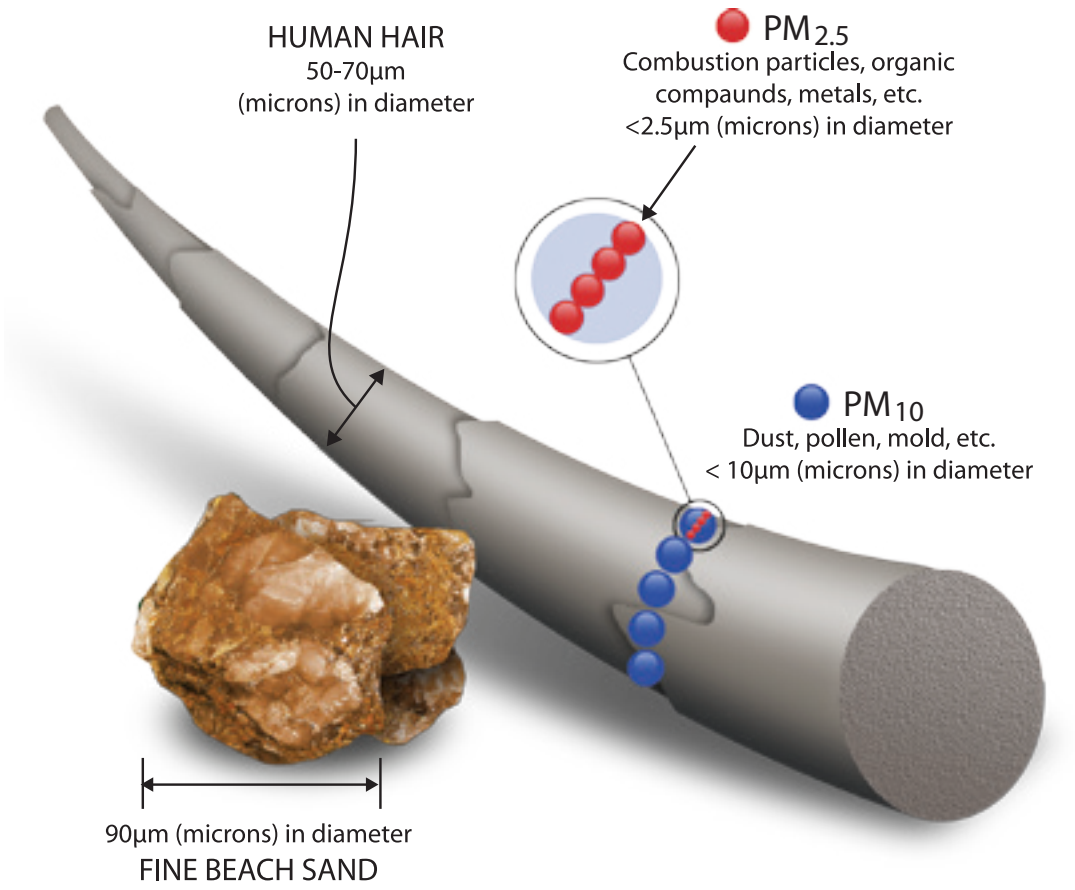
Coal-fired power plants are a primary source and a secondary source because gases from fuel combustion react with other components in the atmosphere to produce particulate matter. Numerous other sources emit gases that react in the air to also form particulate matter (Figure 3).

Particulate matter is often classified into three size-based categories, using aerodynamic diameters measured in micrometers (μm). Though the average diameter of a human hair is approximately 70 μm, PM particles are far smaller (Figure 4)[23].

- Coarse: particles between 2.5 and 10 um (PM_{10})
- Fine: particles between 0.1 and 2.5 um ($PM_{2.5}$)
- Ultrafine: particles less than 0.1 um.

Particulate matter 2.5 micrometers in diameter and smaller ($PM_{2.5}$), such as those found in smoke and haze, can be directly emitted from sources such as forest fires (26%), road dust (22%), electricity generating power plants (11%), industrial processes (11%), and cars and trucks (10%). Numerous other sources emit gases that react in the air to also form $PM_{2.5}$. Elemental and organic carbon, sulfates, nitrates, and metals are all primary constituents of outdoor $PM_{2.5}$.[22]

Figure 4. Graphic representation of size of $PM_{2.5}$ and PM_{10} particles. [22]



WHAT ARE THE HEALTH EFFECTS OF PARTICULATE MATTER?

The size of particulate matter is directly linked to its potential for causing health problems. Smaller is not better. Data show that smaller particles, $PM_{2.5}$ and ultrafine PM, are most strongly associated with a variety of acute and chronic adverse health effects[24,25,26] Because of their smaller size, these smaller particles can enter deeply into the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. Also, the concentration of particulate matter in air, measured in micrograms per cubic meter ($\mu g/m3$), is associated with health effects.[24,27,28,29] Several large, population-based studies of chronic health effects found increases in concentrations of $PM_{2.5}$ of 10 $\mu g/m3$ correlated with increases of 4%–16% in death rates for all causes, including higher rates observed for cardiopulmonary deaths.[28,29,30]

To date, scientists have not established whether the biological relationships between particulate matter and health are attributable to specific chemical components of particulate matter or to the total mass, size, or some combination of these variables.[31]

Adverse health outcomes associated with particulate matter (of various sizes and sources) include[24,27,29,31,32]

- Increased numbers of hospital admissions and emergency room visits for respiratory and cardiovascular conditions
- Exacerbation of asthma symptoms
- Adverse birth outcomes[33,34,35]
- Decreased lung function
- Increased lung cancer incidence
- Premature deaths

Children, the elderly, people with diabetes, and people with heart or lung disease are at greatest risk of adverse health effects from exposure to particulate matter.[1,36]

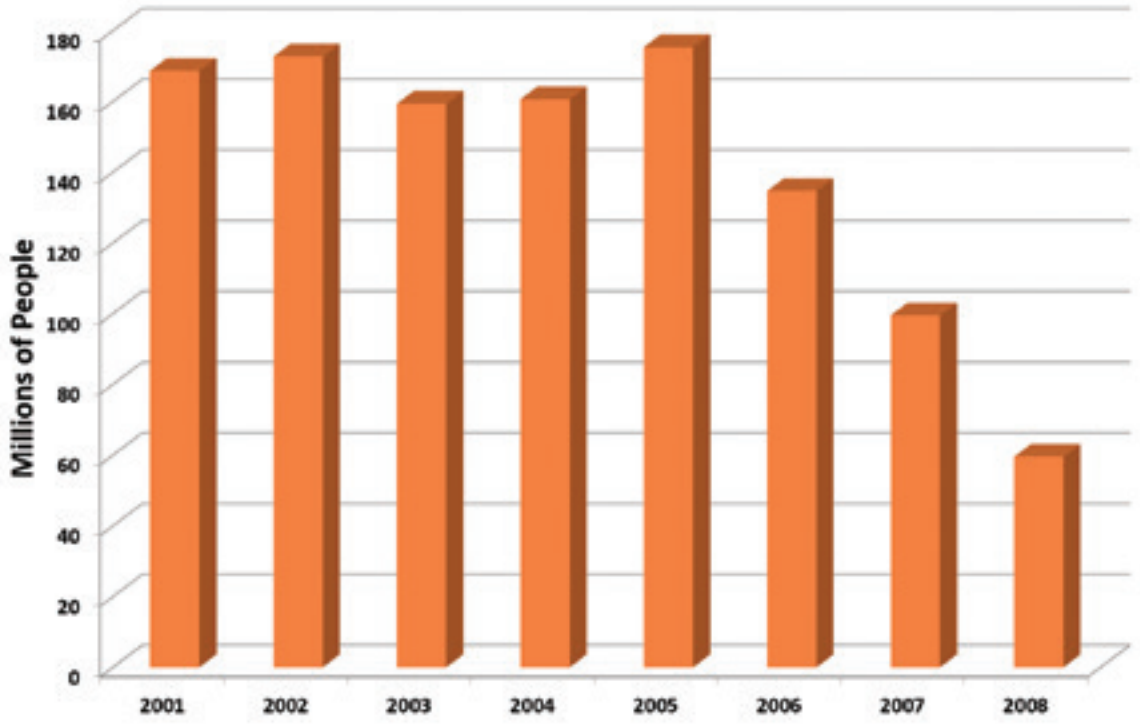


Figure 5. Number of people (in millions) living in counties with $PM_{2.5}$ monitoring measurements greater than the NAAQS 2001-2008 (EPA AQS)[21]

OUTDOOR AIR QUALITY

TRENDS FOR PARTICULATE MATTER

Like ozone, particulate matter levels across the United States are decreasing. PM_{10} levels decreased 27% from 2000 to 2012, and annual $PM_{2.5}$ levels have decreased 33% from 2000 to 2012.[37] Despite these encouraging, declining trends, millions of people continue to be exposed to $PM_{2.5}$ levels that exceed the annual average U.S. standard of 12 $\mu g/m^3$. Moreover, new scientific evidence suggests that excess disease and death persist at $PM_{2.5}$ concentrations less than the current national standard.[14,27,38]

From 2001 to 2008, about 19% (582 of 3,141) of U.S. counties collected sufficient $PM_{2.5}$ monitoring data to generate estimates of exposure that take into account the size of the county population and the number of days that $PM_{2.5}$ levels exceeded the National Ambient Air Quality Standards (NAAQS). Figure 5 shows the number of people living in counties where measured $PM_{2.5}$ concentrations exceeded the NAAQS from 2001 to 2008. A decreasing number of persons may have been exposed to $PM_{2.5}$ concentrations greater than standard levels.

OTHER AIR POLLUTANTS

Currently, 187 HAPs are targeted for emission reductions by the Environmental Protection Agency (EPA), states, and localities. In 1999, the EPA conducted the first National Air Toxics Assessment to focus on estimating the risk of cancer and other serious health effects from breathing air toxics. The results at the time suggested that benzene was most strongly associated with increased cancer risk.[39] Benzene is a product of fuel combustion, primarily from cars, trucks, trains, and aircraft.

WHAT IS BENZENE?

Benzene is widely used as an industrial solvent, an intermediate in the formation of chemical compounds, and a component of gasoline.[40] Based on the EPA's national emissions inventory, the key sources for benzene are on road (49%) and nonroad mobile sources (19%) and open burning, prescribed fires and wildfires (14%). Residential heating from wood combustion accounts for approximately 6% of the total benzene emissions.[41]

HEALTH EFFECTS OF BENZENE

Benzene is a known human carcinogen, linked with increased incidence of leukemia. Acute inhalation exposure may cause health issues: headaches; eye, skin, and respiratory tract irritation; and, at high concentrations, unconsciousness and death. Chronic inhalation exposure in occupational settings has been associated with blood disorders like aplastic anemia. Benzene may also affect reproduction and fetal development, although the evidence is less conclusive for these effects.[41]

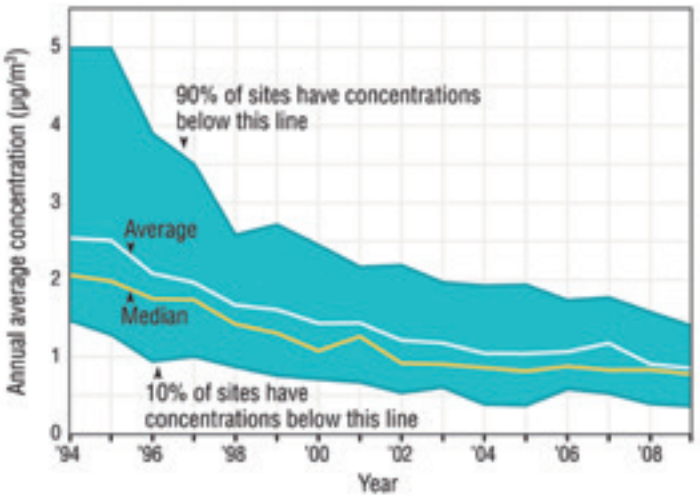
TRACKING BENZENE

Benzene is the most widely monitored, hazardous air pollutant in the United States, but the EPA does not have an ambient benzene air standard. Nationwide, there are 105 monitoring sites for benzene. Emissions of benzene have been tracked for a long time, resulting in a high confidence in benzene emissions estimates.[42] The EPA projects that on road and nonroad mobile ource benzene emissions will decrease by about 60% between 1999–2020 as a result of motor vehicle standards, fuel controls, standards for nonroad engines and equipment, and motor vehicle inspection and maintenance programs. Most of these programs reduce benzene simultaneously with other VOCs.[43]

STATUS AND TRENDS FOR BENZENE

Monitors in urban areas, where benzene levels are generally the highest, tracked a 66% decline in ambient benzene concentrations from 1994 to 2009 (Figure 6). During this time frame, the EPA phased in new car emission standards, mandated cleaner burning gasoline in many cities, and required refineries and chemical plants to significantly reduce benzene emissions.[44]

Figure 6. National annual average concentrations of ambient benzene in urban areas declined by 66 % between 1994 and 2009[45]



[a]**Coverage:** 22 monitoring sites nationwide (out of a total of 339 sites measuring benzene in 2009) that have sufficient data to assess benzene trends since 1994.

Data source: *U.S. EPA, 2010*

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Air Quality Index

AIR QUALITY INDEX (AQI) Values	Levels of Health Concern	PARTICULATE MATTER Cautionary Statements	OZONE Cautionary Statements
0-50	Good	None	None
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.	Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.
101-150	Unhealthy for Sensitive Groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged of heavy exertion outdoors.
151-200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
201-300	Very Unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.	Active children and adults, and people with lung diseases, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors.
301-500	Hazardous	People with heart or lung disease, older adults, and children remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.	Everyone should avoid all physical activity outdoors.

Figure 7. The AQI chart provides cautionary statements for different levels of ozone and PM pollution. (Similar charts are available for other key outdoor air pollutants like carbon monoxide at http://www.airnow.gov/)[46]

PREVENT AIR POLLUTION EXPOSURE

Air pollution exposure depends in part on where people live and work and the time they spend outside. The Air Quality Index (AQI) offers forecasts of ozone and particulate matter on a national and state level and in some metropolitan areas and national parks. The AQI is an index that reports daily air quality and any associated health effects that might be a concern (Figure 7).

Urban and industrial areas tend to have higher particulate matter concentrations, but natural sources, such as forest fires, volcanoes, and dust storms, can also be a source of high particulate matter concentrations. Indoor sources, such as wood-burning stoves and fireplaces, can contribute significantly to exposure as well.

Filtering systems reduce particulate matter emissions at pollution sources, such as power plants and metal refineries. In addition, limits on the gaseous emissions that can contribute to particulate matter formation, including sulfur dioxide from coal-fired power plants, has contributed to reductions of particulate matter in the Midwest and Southeast United States.

WHAT CAN YOU DO TO REDUCE YOUR EXPOSURE TO AIR POLLUTION?

- Check the Air Quality Index and take steps to reduce your exposure to air pollutants when levels are high, such as:
  - Reduce the amount of time spent outside.
  - Reduce heavy or prolonged exertion while engaged in outdoor activities.
  - Plan outdoor activities when air pollutant levels are lower, usually in the morning and evening.
  - Avoid areas with a high traffic volume.[47]
- Do not smoke and do not allow others to smoke in your living space.
- Reduce your use of indoor wood-burning stoves and fireplaces and use good ventilation.
- Avoid inhaling fumes and skin contact with gasoline while pumping gas.[48]
- Minimize exposure to vehicle exhaust.

ADDITIONAL RESOURCES

- Air Now at http://airnow.gov
- A Guide to Air Quality and Your Health at http://www3.epa.gov/airnow/aqi_brochure_02_14.pdf
- "About Air Toxics" at http://www.epa.gov/air/toxicair/newtoxics.html
- "Evaluating Exposures to Toxic Air Pollutants: A Citizen's Guide" at http://www3.epa.gov/airtoxics/3_90_023.html

REFERENCES

1. American Lung Association (ALA). State of the air 2013 [online]. 2013. [cited 2013 Aug 14]. Available from URL: http://www.lung.org/healthy-air/outdoor/protecting-your-health/impacts-on-your-health/

2. U.S. Environmental Protection Agency (EPA), Our Nation's Air—Status and Trends Through 2010 [online].Feb 2012. [Cited] Available from URL: http://www.epa.gov/airtrends/2011/index.html.

3. EPA, Air Quality Planning and Standards. The Ambient Air Monitoring Program [online]. 2011 Nov 4. [cited 2013 Aug 14]. Available from URL: http://www.epa.gov/airquality/qa/monprog.html.

4. EPA, Technology Transfer Network (TTN). 1999 National-Scale Air Toxics Assessment: Frequent questions [online]. 2010 July 1. [cited 2011 Feb 8]. Available from URL: http://www.epa.gov/ttn/atw/natamain/.

5. Hippocrates. On Airs, Waters and Places. Translated by Francis Adams. The Internet Classics Archive by Daniel C. Stevenson, Web Atomics. World Wide Web presentation is copyright (C) 1994-2000, Daniel C. Stevenson, Web Atomics. Available at URL: http://classics.mit.edu/Hippocrates/airwatpl.mb.txt

6. Avol EL, Linn WS, Venet TG, Shamoo DA, Hackney JD. Acute respiratory effects of ozone and ambient oxidant pollution exposure during heavy exercise. J Air Pollut Control Assoc 1983;34:804–9.

7. Ihorst G, Frischer T, Horak F, Schumacher M, Kopp M, Forster J,et al. Long- and medium-term ozone effects on lung growth including a broad spectrum exposure. Eur Respir J 2004;23(2):292–9.

8. Gauderman WJ, Gilliland GF, Vora H, Avol E, Stram D, McConnell R, et al. Association between air pollution and lung function growth in Southern Californiachildren: results from a second cohort. Am J Respir Crit Care Med 2002;166(1):76–84.

9. U.S. EPA (U.S. Environmental Protection Agency). (2013). Integrated Science Assessment for Ozone and Related Photochemical Oxidants. EPA 600/R-10/076F. Research Triangle Park, NC http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=511347

10. Bell ML, Peng RD, Dominici F. The exposure-response curve for ozone and risk of mortality and the adequacy of current ozone regulations. Environ Health Perspect 2006;114(4):532–6.

11. Vedal S, Brauer M, White R, Petkau J. Air pollution and daily mortality in a city with low levels of pollution. Environ Health Perspect 2003;111(1):45–51.

12. Anderson HR, Atkinson RW, Peacock JL, Marston L, Konstantinou K. Meta-analysis of time-series studies and panel studies of particulate matter (PM) and ozone (O3).

13. Copenhagen (Denmark):World Health Organization, Regional Office for Europe; 2004.

14. Gent JF, Triche EW, Holford TR, Belanger K, Bracken MB, Beckett WS, et al. Association of low-level ozone and fine particles with respiratory symptoms in children with asthma. JAMA 2003;290(14):1859–67.

15. White MC, Etzel RA, Wilcox WD, Lloyd C. Exacerbations of childhood asthma and ozone pollution in Atlanta. Environ Res 1994;65(1):56–68.

16. Thurston GD, Ito K, Hayes CG, Bates DV, Lippmann M. Respiratory hospital admissions and summertime haze air pollution in Toronto, Ontario: consideration of the role of acid aerosols. Environ Res 1994;65(2):271–90.

17. Triche EW, Gent JF, Holford TR, Belanger K, Bracken MB, Beckett WS, et al. Low-level ozone exposure and respiratory symptoms in infants. Environ Health Perspect 2006;114(6):911–6.

18. McConnell R, Berhane K, Gilliland F, London SJ, Islam T, Gauderman WJ, et al. Asthma in exercising children exposed to ozone: A cohort study. Lancet 2002;359(9304):386–91.

19. Brunekreef B, Hoek G, Breugelmans O, Leentvaar M. Respiratory effects of low level photochemical air pollution in amateur cyclists. Am J Respir Crit Care Med 1994;150(4):962–6.

20. Höppe P, Peters A, Rabe G, Praml G, Lindner J, Jakobi G, et al. Environmentalozone effects in different population subgroups. Int J Hyg Environ Health 2003;206(6):505–16.

21. EPA. Ozone: national trends in ozone levels [online]. 2010 Dec 17. [cited 2011 Feb 9].Available from URL: http://www.epa.gov/airtrends/ozone.html.

22. EPA, TTN, Air Quality System. Download detailed AQS data [online]. 2011 Mar. [cited 2011 Apr 25]. Available from URL: http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm.

23. EPA, Air Emissions Sources. Particulate matter, 2014 [online]. 2014 May 8. [cited 2014 May 8]. Available from URL: http://www.epa.gov/cgi-bin/broker?_service=data&_debug=0&_program=dataprog.national_1.sas&polchoice=PM.

24. EPA. Particulate matter research [online]. 2013. [cited 2014 May 8]. Available from URL: http://www.epa.gov/research/airscience/air-particulatematter.htm.

25. Pope CA, Dockery DW. Health effects of fine particulate air pollution: Lines that connect. Journal of the Air & Waste Management Association 2006; 56: 709-742.

26. Brook RD, Rajagopalan S, Pope CA, Brook JR, Bhatnagar A, Diez-Roux AV, Holguin F, Hong YL, Luepker RV, Mittleman MA, Peters A, Siscovick D, Smith SC, Whitsel L, Kaufman JD, Epidemiol AHAC, Dis CKC, Metab CNPA. Particulate Matter Air Pollution and Cardiovascular Disease An Update to the Scientific Statement From the American Heart Association. Circulation 2010; 121: 2331-2378.

27. Miller KA, Siscovick DS, Sheppard L, Shepherd K, Sullivan JH, Anderson GL, et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. N Engl J Med 2007;356(5):447–58.

28. Samet JM, Dominici F, Curriero FC, Coursac I, Zeger SL. Fine particulate air pollution and mortality in 20 U.S. cities, 1987–1994. N Engl J Med 2000;343(24):1742–9.

29. Pope III CA, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA 2002;287(9):1132–41.

30. Pope III CA, Dockery DW. Health effects of fine particulate air pollution: lines that connect. J Air Waste Manag Assoc 2006;56(6):709–42.

31. Laden F, Schwartz J, Speizer FE, Dockery DW. Reduction in fine particulate air pollution and mortality—extended follow-up of the Harvard six cities study. Am J Respir Crit Care Med 2006;173(6): 667–72.

32. Schwartz J. Air pollution and hospital admissions for heart disease in eight U.S. counties. Epidemiology 1999;10(1):17–22.

33. Sheppard L, Levy D, Norris G, Larson T, Koenig J. Effects of ambient air pollution on nonelderly asthma hospital admissions in Seattle, Washington, 1987–1994. Epidemiology 1999;10(1):23–30.

34. Wilhelm M, Ritz B. Local variations in CO and particulate air pollution and adverse birth outcomes in Los Angeles County, California, USA. Environ Health Perspect 2005;113(9):1212–21.

35. Bell ML, Ebisu K, Belanger K. Ambient air pollution and low birth weight in Connecticut and Massachusetts. Environ Health Perspect 2007 Jul;115(7):1118–24.

36. Ritz B, Yu F, Chapa G, Fruin S. Effect of air pollution on preterm birth among children born in Southern California between 1989 and 1993. Epidemiology 2000;11(5):502–11.

37. EPA. Particle pollution and your health [online]. 2003. [cited 2011 Apr 25]. Available from URL: http://www.epa.gov/airnow/particle/pm-color.pdf.

38. EPA. National Trends in Particulate Matter Levels [online]. 2013 Sep 3. [cited 2013 Dec 13]. Available from URL: http://www.epa.gov/airtrends/pm.html

39. Daniels MJ, Dominici F, Samet JM, Zeger SL. Estimating particulate matter-mortality dose-response curves and threshold levels: an analysis of daily time-series for the 20 largest U.S. cities. Am J Epidemiol 2000;152(5):397–406.

40. EPA, TTN. 1999 national-scale air toxics assessment: summary of results [online]. 2007 Nov. [updated 2010 Jul; cited 2007 Nov 14]. Available from URL: http://www.epa.gov/ttn/atw/nata1999/risksum.html.

41. EPA. Toxicological review of benzene (noncancer effects)[online]. 2002 Oct. [cited 2010 Oct 4]. Available from URL: http://www.epa.gov/ncea/iris/toxreviews/0276tr.pdf.

42. EPA. Benzene [online]. 2012 Jan [cited 2013 Nov 14]. Available from URL: http://www.epa.gov/ttn/atw/hlthef/benzene.html.

43. EPA, TTN. 1996 national-scale air toxics assessment: results of model-to-monitor comparison for benzene [online]. 2010 Apr 15. [cited 2011 Apr 26]. Available from URL: http://www.epa.gov/ttn/atw/nata/benz.html.

44. EPA, TTN.1999 national-scale air toxics assessment estimated emissions, concentrations, and risk [online]. 2010 Jul 1. [cited 2010 Oct 5]. Available from URL: http://www.epa.gov/ttn/atw/nata1999/natafinalfact.html.

45. EPA. National air quality and emissions trends report, 2003. Chapter 5: Air toxics [online]. 2003 Sept. [updated 2010; cited 2007 Nov 11]. Available from URL: http://epa.gov/air/airtrends/aqtrnd03/pdfs/chap5_airtoxics.pdf.

46. EPA. Report on the environment: Ambient concentrations of benzene [online]. 2009. [updated 2010 Dec 14; cited 2010 Apr 19]. Available from URL: http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewInd&lv=list.listByAlpha&r=216617&subtop=341.

47. EPA. Air quality index: a guide to air quality and your health [online]. 2009 Aug. EPA-456/F-09-002 [cited 20013 Nov 21]. Available from URL: http://www.epa.gov/airnow/aqi_brochure_08-09.pdf

48. EPA. Regulatory impact analysis: control of hazardous air pollutants from mobile sources. Chapter 3: Air quality and resulting health and welfare effects of air pollution from mobile sources [online]. 2007 Feb. [cited 2007 Nov 15]. Available from URL: http://www.epa.gov/otaq/regs/toxics/420r07002chp3.pdf.

49. CDC, Agency for Toxic Substances and Disease Registry. Toxic substances portal— benzene: Medical management guidelines for benzene [online]. 2007 Sept. [cited 20013 Nov 21]. Available from URL: http://www.atsdr.cdc.gov/MHMI/mmg3.html.