Air Pollution: Effects on Children

User Guide

I. Case Study

Jessica, is a 10 yr old female with severe eczema, allergic rhinitis and moderate persistent asthma. She is followed by her Primary Care Physician. Her asthma is triggered by heat, dust, exercise and allergies. She lives in a 150 yr old farm house. While she uses her albuterol daily, she presents, today, to the ED with an exacerbation of her asthma after playing outside. She is admitted to the hospital as she was in her Red Zone per her Asthma Action Plan (AAP):

- Green Zone: Flovent 110 mcg 2 puffs BID and Singulair 5mg Daily
- Yellow Zone: Flovent 110mcg 4puffs BID
- Red Zone: 40 mg Prednisone

Upon investigation, you discover that the Air Quality Index, today, was 150. This is her first day of school and was allowed to go outside for recess.

Questions:
1. How can outdoor air quality affect this child’s health?
2. What is the Air Quality Index and how it applies to children’s activities and schools?
3. Who is responsible for ensuring this child’s family and school is appropriately educated regarding asthma and the outdoor environment?

II. Introduction

Although outdoor air quality in the United States has improved in recent decades, current levels of ambient air pollution continue to contribute to adverse health effects among the most susceptible members of society. In addition, it has become more apparent that there is a direct correlation between outdoor and indoor air quality. The purpose of this module is to review current information about hazards found in the air that children breathe outdoors.

Children are not little adults. This statement is particularly true when it comes to assessing the impact of environmental hazards on children’s health. Children are experiencing rapid lung development and compared to adults, have different breathing zones, a greater respiration rate, and engage in more physical activity. While there are a number of reasons for this, the health effects pertaining to air pollution are largely due to the immaturity of the lungs and
differences in their respiratory function. The human lung, at birth, is a largely immature organ and has only a fraction of the adult number of alveoli and blood vessels. During the first year of life, alveoli (air sacs) in the lung form at a high rate to increase in number similar to that of an adult. Blood vessel formation in the lung is ongoing and is not complete until 2-3 years of life. Based on this, a child’s lung can be considered a miniaturized version of the adult lung at the age of about 3 years. From this age until young adulthood, the lung grows in proportion to lung volume and body weight. In fact, between birth and young adulthood, the lung volume increases by as much as 23-fold.

Exposure to toxicants during lung development has the potential to affect the overall growth and function of the respiratory system in infants and children and can impact the risk for developing adult lung disease. In addition, exposures during different stages of childhood may result in different adult disease presentations depending on the stage of maturation of the lung. These “windows of susceptibility” can affect the lungs and airways and result in consequences through the lifetime.

In addition, older children tend to spend more time outdoors compared to adults. These would result in increased exposure to environmental pollutants including nitrogen oxides, persistent organic pollutants, sulfur oxides, ground level ozone and particulate matter. Effects may be immediate or may surface years after exposure.

Learning Objectives
After completing this module, faculty will be able to teach students and residents to:
• Identify sources of outdoor air pollution
• Understand how children are at higher risk for health effects from air pollution
• Utilize the air quality index to prevent exposures to high risk children

III. What are the components of air pollution?

Sources of outdoor pollution include transportation, industry, electrical power generation, refuse disposal, and residential wood combustion, as well as natural sources such as wildfires. The major outdoor air pollutants are sulfur oxides, hydrocarbons, ozone, particulate matter, and nitrogen oxides. An extensive body of literature suggests that outdoor air pollution contributes to respiratory and cardiovascular mortality (adults), increases in asthma exacerbations and respiratory symptoms, and eye and throat irritation. Exposure to other agents such as environmental tobacco smoke or allergens may exacerbate the effect of outdoor air pollution.

Hazardous air pollutants, also known as toxic air pollutants (air toxics), are those pollutants that can cause cancer or other serious health effects. The Environmental Protection Agency (EPA) currently controls 187 air pollutants including benzene, perchlorethylene and methylene chloride (www.epa.gov/air/airpollutants.html). Most air toxics are from man-made sources including transportation, factories and power plants. Most of the substances on this list contain
certain volatile organic chemicals, pesticides, herbicides and radionuclides that, based on scientific studies, can cause harm to humans and other mammals.

**Ozone**

Ozone (O₃), a gas with a pungent odor that is often smelled after electrical storms, is bluish in color at higher-than-ambient concentrations. There is much confusion over the difference between “good” ozone and “bad” ozone. “Good” ozone is the diffuse layer of ozone gas in the stratosphere, 10-25 miles above the earth that screens out the sun’s most damaging ultraviolet rays. This ozone shield has been damaged by human activities, particularly by chlorofluorocarbons (CFCs), which have been used as refrigerants and aerosol propellants. “Bad” ozone is formed at ground level when reactive hydrocarbons are mixed with nitrogen oxides in the presence of sunlight. This type of ozone is formed only during the daylight hours and is the main photochemical oxidant in smog. April through September are the months when ground-level ozone is a public health concern in most parts of the United States. Exposure to ground-level ozone has been found to result in short-term symptoms such as cough, throat irritation, increased mucous production, chest discomfort, malaise and nausea, and headache. Exercise exacerbates the effects of ozone in susceptible individuals. Except in a few recent projects, chronic effects on lung function due to O₃ exposure have not been shown. However, studies have repeatedly demonstrated transient decreases in lung function due to O₃ exposure.

**Sulfur Dioxide**

Sulfur dioxide (SO₂) is a colorless, water-soluble gas. It is derived from the combustion of sulfur-containing fossil fuels such as brown coal and oil. Other sources include the smelting of sulfur-containing ores, volcanic eruptions, and the commercial drying of fruits. Ninety percent of SO₂ is absorbed in the upper respiratory tract, with only slight penetration in the lower respiratory tract. Numerous studies have shown that SO₂ exposure is associated with decreases in lung function and increases in hospitalization. This effect is independent from that of particulate air pollution. Although SO₂ levels have decreased in major U.S. cities, SO₂ exposure is still of concern in children with asthma, who may be more susceptible to the bronchoconstrictive effects of SO₂.

**Acid Aerosols**

Acid rain occurs when SO₂ and oxides of nitrogen (NOₓ) react with water, oxygen, sunlight, and oxidants in the atmosphere to form acidic aerosols. Acid manufacturing plants and fertilizer and pigment factories are primary sources of acid aerosols. These compounds are also formed when SO₂ or SO₃ come into contact with mucous membranes. Excess hospital admissions for respiratory diseases and increases in asthma exacerbations have been associated with airborne sulfate (SO₃) levels.

**Particulate Matter (PM)**

There are a number of terms for particulate matter (PM): black smoke, TSP (total suspended particles), and PM10 (particulate matter with an aerodynamic diameter of less than 10 microns). Increasing attention is being paid to smaller “fine” particles (PM2.5), which are
deposited more deeply in the lung, and can potentially damage the lower airways and alveoli. The primary sources of particulate matter are vehicular traffic (gasoline and diesel engines), power plants, industrial incinerators, volcanoes, road dust, dust storms, and residential wood combustion. Particulate matter has been associated with increases in the prevalence of chronic bronchitis, respiratory symptoms, and reductions in peak expiratory flow (PEF). Adverse health effects have been found in time-series studies of daily counts of respiratory morbidity and mortality, primarily among persons with respiratory and cardiovascular conditions.

**Oxides of Nitrogen (NOx)**

NO and NO2 are formed during the burning of fossil fuels, particularly by motor vehicle engines. NO2 contributes to the formation of ground-level ozone and may contribute significantly to indoor levels of this compound. In the presence of NO2, bronchial mucosa may become more permeable to allergens, decreasing the threshold necessary for sensitization and increasing the incidence of allergic asthma. Increased airway responsiveness has been linked to exposure to high levels of ambient NO2. In general, however, NO2 is more of a concern as an indoor rather than outdoor pollutant.

**IV. Characteristics**

As mentioned previously, air pollution has been linked to adverse respiratory health outcomes in children. The most common health effect is the trigger of asthma symptoms that may be severe leading to death. Asthma is a disease that affects your lungs resulting in cough, wheezing, breathlessness, and chest tightness. Some of the most common triggers include tobacco smoke, dust mites, cockroach allergens, pets, and outdoor air pollution. Illnesses, such as respiratory viruses (influenza, colds and respiratory syncytial virus), sinus infections and allergies may also cause asthma symptoms. Thus, outdoor air pollution is only one trigger on the differential to avoid. However, this pollution can come from multiple sources (as described above). Thus, it is imperative that people with asthma pay attention to the air quality index (http://www.airnow.gov) to prevent exposures to these pollutants.

Scientific studies have linked air pollution to other health problems including: (1) aggravation of respiratory and cardiovascular disease; (2) decreased lung function; (3) increased frequency and severity of respiratory symptoms such as difficulty breathing and coughing; (4) increased susceptibility to respiratory infections; (5) effects on the nervous system, including the brain, such as IQ loss and impacts on learning, memory, and behavior; (6) cancer; and (7) premature death (Source: Environmental Protection Agency).

Most environmental diseases either manifest as common medical problems or have nonspecific symptoms that make the ultimate diagnosis difficult. Thus, suspecting an environmental cause for any disease is imperative not only for diagnosis but also for management. Thus, one needs to incorporate an exposure history questionnaire into practice. Although many clinicians recognize the importance of taking an occupation and exposure history, few have expertise or training in this area. Completing an exposure history form prior to or during a physician visit,
will guide the practitioner on possible etiologies of the symptoms and disease. The “Environmental History-Taking” module in the Children’s Environmental Health Network’s (CEHN) Pediatric Environmental Health Training Resource provides an excellent starting point to learn more about this, and tools and resources to begin integrating environmental history taking into clinical practice.

V. Clinical symptoms and signs related to exposure

Many studies have shown that there are consistent short-term effects of air pollution on health outcomes as assessed by hospital admissions or deaths. In addition to acute effects, some cohort studies have shown long-term health effects of air pollution. Key to these findings is that the effects are not from isolated chemicals, but there may be synergism of effects with exposure from the combination of chemicals in the air.

Children in counties with high ozone and, to some degree, particulate matter levels are more likely to have current asthma and/or recent asthma attacks compared to children living in counties with lower air pollution. This may, in part, be due to the significant deficits in lung function growth rates associated with exposure to acid vapor, NO2, small particulate matter and elemental carbon.

Air pollution can have both long and short term health effects with exposures. Fine particulate matter is associated with a broad spectrum of acute and chronic illness, such as lung cancer and cardiopulmonary disease. Worldwide, it is estimated to cause about 9% of lung cancer deaths, 5% of cardiopulmonary deaths and about 1% of respiratory infection deaths. Particulate matter pollution is an environmental health problem that affects people worldwide, but middle-income countries disproportionately experience this burden. In addition, more vulnerable populations like children and elderly are more susceptible to the adverse health effects from air pollution.

VI. Treatment and Prevention

Treatment of the health effects that occur from exposure to chemicals in air pollution is dependent on the presentation (symptoms and severity) of disease. Providers should be well prepared to treat patients with acute exacerbations of asthma symptoms with oxygen, bronchodilators and steroids. The “Environmental Management of Pediatric Asthma: Guidelines for Health Care Providers” module in CEHN’s Pediatric Environmental Health Training Resource has intervention tips and resources to improve indoor air quality as well. Expedient therapy may be necessary in many cases. Other diagnoses such as cardiovascular disease and skin conditions depend on the presenting symptoms and may require referral to specialists for diagnosis.
However, this pollution can come from multiple sources (as described above). Thus, it is imperative that people with asthma pay attention to the air quality index (http://www.airnow.gov) to prevent exposures to these pollutants.

VII. Advice to Parents

*How can I find out about the outdoor air quality in my community?*
Information about air quality in communities can be found in the newspaper and the radio. Additionally, you can find this information at http://www.airnow.gov.

*How can I protect my child from outdoor air pollution when they want to play outdoors?*
The degree of air pollution can change day to day and throughout the day. While exposure to air pollution cannot be entirely prevented, children can be protected by knowing the air quality index and keeping them inside when the value is high. This is especially important for children with respiratory problems and during strenuous activity. On days when the afternoons are expected to have worse air quality (ozone alerts), children should be kept indoors. Most states have specific rules for schools as they apply to outdoor activities and poor air quality. These activities should be rescheduled for times of the day when air quality is improved (morning or evening).

*What can I do to help my child and community if we live in an area with high air pollution?*
It is very important for parents and physicians to discuss these concerns. The child’s environment includes the home, school, work and play. All should be assessed for safety for the overall health of the child. If the parent and/or physician believe that the child is exposed to an excessive amount of air pollution due to emissions, local and state environmental agencies should be notified.

Other immediate options are available. Windows and doors should be closed during peak hours of poor air quality, and the air conditioner should be set to recirculate. Schools should enforce a no idling zone for buses and cars that drop off children. Lastly, local and state agencies should be encouraged to reduce motor vehicle emissions and adopt reduction strategies for schools and homes built near high-traffic roads.

VIII. Summarize Key points

- Although outdoor air quality in the United States has improved in recent decades, current levels of ambient air pollution continue to contribute to adverse health effects among the most susceptible members of society.

- Exposure to toxicants during lung development has the potential to affect the overall growth and function of the respiratory system in infants and children and can impact the risk for developing adult lung disease.
- Air pollution can have both long and short term health effects with exposures. The most common heath effect is the trigger of asthma symptoms that may be severe leading to death. Treatment of the health effects that occur from exposure to chemicals in air pollution is dependent on the presentation (symptoms and severity) of disease.

- Sources of outdoor pollution include transportation, industry, electrical power generation, refuse disposal, and residential wood combustion, as well as natural sources such as wildfires.

- The major outdoor air pollutants are sulfur oxides, hydrocarbons, ozone, particulate matter, and nitrogen oxides.

- During periods with poor air quality, outdoor physical activity should be prevented based on the Air Quality Index.
KEY RESOURCES FOR FURTHER READING


Note: This User Guide is intended to accompany the PowerPoint module of the same name. It elaborates on some studies which may require more in-depth information than what is provided on the slides. However, the contents of all slides in the module are equally important to present.

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