Allergies and Asthma: Adaptations to Pollution

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Introduction

Recent studies have shown an increase in atmospheric concentration of air pollutants correlates with an increase in allergic respiratory diseases. Pollutants affect the different types of airborne allergies and where they can be located (D'Amato, 2002). Population, the economy, and the use of on-road vehicles have increased substantially over the past few decades. There are many health risks associated with air pollutants. Chronic respiratory diseases, cardiovascular diseases, and lung cancer are among the most serious. Asthma in children has more than doubled in the U.S. over the past two decades (Woolcock, 1997).

Climate change can also affect exposure to air pollutants. A change in climate affects weather as well as anthropogenic and biogenic emissions (Bernard et al., 2001). Local weather patterns influence atmospheric chemical reactions as well as atmospheric transport processes (Bernard et al. 2001). Local weather patterns include temperature, atmospheric water vapor, wind speed, and wind direction (Bernard et al., 2001).

It is important to understand the dangers associated with pollution and the effects that it may have on the health of each individual person. Numerous experiments have been conducted and they have found a parallel between increases in pollution and respiratory diseases. The purpose of this paper is to show that correlation and look at the adaptations that need to occur in order for the problem to decrease.

Correlation Between Pollution and Respiratory Disease

Particulate matter can lead to chronic respiratory and cardiovascular disease (Bernard et al., 2001). Ground level ozone can aggravate chronic respiratory diseases and cause short-term reductions in lung function (Bernard et al, 2001). In Donora,
Pennsylvania an air pollution event caused by thermal inversions confined industrial combustion emissions at ground level. It lasted over a 5-day period in October 1948 and caused 19 deaths, which was above the 2 deaths expected for this period (Bernard et al., 2001). The sudden increase in illness and death was associated with high concentrations of particulate matter and SO₂ (Bernard et al, 2001).

Pollutants have many different sources. There are natural polluters such as volcanoes and the rotting of vegetation. There are also agricultural polluters such as methane and pesticides. An example of a source of commercial polluter would be automobile repair shops. There are also industrial polluters which would be power plants and manufacturing buildings. Transportation is another type of polluter. Just as pollution comes from all these outside sources, it can also come from an individual's home. Home gas and oil burners add to the concentration of air pollution (Bernard et al., 2001). Because of all the different types of air pollution, people are almost always exposed to some type of pollution, whether they know it or not (Bernard et al., 2001).

Climate change can affect a person's exposure to air pollutants by affecting weather and thus pollution concentrations (Robinson, 1989). Weather is associated with energy demands that could change patterns of fossil fuel combustion (Bernard et al., 2001). For example, hot weather can lead to large increases in air conditioner use. Seasonal differences in natural emissions of VOCs and NO indicate that warmer temperatures are linked with increased natural emissions. An increase of 10°C can cause over a 2-fold increase in both VOCs and NO biogenic emissions (Bernard et al, 2001).

Humans have found ways to adapt to the changing environmental conditions. When it is hot outside people turn up their air conditioners. When it is cold outside the
heaters come into use. However, home gas and oil burners are also sources of residential pollutants (Bernard et al., 2001). Sources of NO$_2$ include cooking stoves and space heaters. Elevated levels of NO$_2$ may result when an unvented gas space heater is used (Bernard et al., 2001). As a means of adapting to changes in the environment people run a risk of increasing their intake of pollution.

It has been hypothesized that changes in the climate, such as, increased temperature, wind speed and direction and precipitation can either increase or decrease a person’s exposure to natural allergens (Bernard et al., 2001). Pollen concentration varies as a result of seasonal change. Pollen counts increase with temperature and this in turn may lead to an increase in allergies (Bernard et al., 2001). Studies that have been conducted are unable to give a definite causal relationship to climate change and allergen related incidence however, there is evidence that an increase allergic rhinitis is correlated strongly with increase land use change and farming practices (Emberlin, 1994). Tractors and other fuel based machines are being used more (Emberlin, 1994).

Increases to dust exposure may increase the likelihood to asthma (Etzel, 2003). An investigation of an asthma cluster in Toledo, Ohio found that 200 of the patients lived within one-mile radius of a castor bean mill. Many of the patients asserted that their attacks coincided with the odor of linseed oil emitting from the mill when the wind blew in their direction. The mill was also producing castor oil from castor beans. Investigators found that that a fine dust produced from the beans was being carried in the wind. The outbreak of asthma attacks in Toledo was documented to have been caused by the inhalation of castor bean grinding dust (Etzel, 2003). Fungal growth increases with a
rise in temperature. Particulate-carried fungal spores also increase with a rise in temperature.

Air pollutants CO, lead, NO₂, O₃, PM, and SO₂ are the current six criteria air pollutants (Bernard et al., 2001). Most of the criteria air pollutants are formed from fossil fuel combustion. This chart displays the national air pollutant emissions and concentrations spanning from 1988 to 1997:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O₃</td>
<td>24.027</td>
<td>19.214</td>
<td>-20</td>
<td>-19</td>
</tr>
<tr>
<td>NOₓ</td>
<td>23.718</td>
<td>23.582</td>
<td>-1</td>
<td>-14</td>
</tr>
<tr>
<td>SO₂</td>
<td>23.154</td>
<td>20.369</td>
<td>-12</td>
<td>-39</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>3.528</td>
<td>3.112</td>
<td>-12</td>
<td>-26</td>
</tr>
<tr>
<td>CO</td>
<td>116.081</td>
<td>87.451</td>
<td>-25</td>
<td>-38</td>
</tr>
<tr>
<td>Lead</td>
<td>7.053</td>
<td>3.915</td>
<td>-44</td>
<td>-67</td>
</tr>
</tbody>
</table>

![National Air Pollutant Emissions and Concentrations](image)
O₃ is the main pollutant for photochemical pollutions. This type of pollutant harms the epithelial surfaces which take them in. In vitro studies using very high concentrations of O₃ suggest that O₃ has a low potential to cause mutagenic, cytogenic, or cellular transformation effects (Bernard et al., 2001). Volatile organic compounds (VOCs) and NOₓ in the presence of sunlight are the main sources for the production of the pollutant O₃. VOCs get formed from automobile emissions, chemical plants, factories, and other industrialized sources (Bernard et al., 2001). NOₓ also gets produced from automobiles, as well as fossil fuel-fired plants, and natural sources such as lightning (Bernard et al., 2001). The U.S. EPA National Air Quality and Emissions Trends Report from 1995 used animal tests and in vitro studies to show there is an increase in the inflammation of airways as well as a decrease in host defense functioning if there is an over-exposure to O₃.

Health effects of air pollution have gained much attention over the past few decades. The Air Pollution and Health: the European Approach (APHEA) project used data from daily pollutant levels of 15 European cities with a population of more than 25 million. It was found that an increase of NO₂ and O₃ was correlated with a 1.3% and 2.9% increase in daily all-cause mortality, and a 50-mcg/m³ increase in 24-h average NO₂ alone was associated with an increase in 2.6% in asthma admissions (Spix and Anderson, 1998).

The effects of air pollution on the respiratory system are dependent on many things. First it is important to look at the type of pollutant and its concentration in the atmosphere. Second, one must observe the amount of time a person is exposed to that
pollutant. A predisposition to develop a respiratory problem must also be taken into account (D'Amato, 2002).

**Children's Vulnerability**

Asthma is the most common chronic disease in children found in developed nations (Lee et al., 2003). It is estimated that 20 million Americans suffer from asthma. Of these 10 million (3 million children) suffer specifically from allergic asthma according to the National Institute of Environmental Health Sciences. The prevalence of asthma morbidity and mortality has increased in the United States from 6.7 million in 1980 to 17 million in 1998 (Etzel, 2003).

Lee et al. conducted a study to find out the risk factors, estimate the population risk of each exposure, and compare the data for boys versus girls for physician-diagnosed asthma in Taiwanese schoolchildren. Using a cross-sectional national survey, 35,036 6- to 15-year-old school children were chosen. Hereditary and indoor and outdoor environmental factors for childhood asthma were investigated by questionnaire. Outdoor air pollutants were associated with parent-reported perceived ambient air pollution. Asthma was reported for 8.1% of the boys and 5.6% of the girls. The risk of asthma was significantly correlated with parental atopy and perceived ambient air pollution in both sexes. The presence of cockroaches, mold on walls at home, and water damage were also associated with asthma in girls; although, only mold on walls at home was related to asthma in boys.

The most common air pollutants from traffic-related causes are inhalable particulate matter (PM$_{10}$ and PM$_{2.5}$), nitrogen dioxide (NO$_2$), and ozone (O$_3$) (D'Amato, 2002). Devalia et al. studied the effect of previous exposure to ozone and nitrogen dioxide on
subsequent allergen-induced changes in the nasal mucosa of patients with seasonal allergic rhinitis. The results show that the inhalation of these substances either together, or individually, can increase the airway response to inhaled allergens by releasing eosinophil cationic protein in nasal lavage (Devalia et al., 1998). The studies have shown that these substances inflame the airway and increase both the immediate- and late-phase response to inhaled allergens (D'Amato, 2002). Motor vehicle fumes have been found to sensitize children's airways. This can trigger allergies and inflammation (Coghlan, 2003). There are no studies, however, that can show pollution causes allergies or asthma (Lee et al., 2003). The epidemiological studies have only shown correlations. Outdoor air exposures are probably not the cause for the increase in asthma. Outdoor air pollutants are more likely to cause increase in asthma exacerbations (Etzel, 2003).

Healthy children exposed to low O₃ concentrations can develop lung inflammation as well as breathing impairment (Bernard et al., 2001). Asthma currently affects nearly 5 million children in the United States. In children four years or younger, the prevalence increased 160% from 1980 to 1994 (Woolcock, 1997). Levels of O₃ tend to be greatest with a high temperature. For example, the hot weather conditions in 1995 in the Central and Eastern United States were highly conducive to the development of O₃ (Bernard et al., 2001). Children exposed to this type of environment may have a slight, but significant, decrease in pulmonary function (Etzel, 2003).

There is also the matter of indoor pollution. Indoor pollutants may have a more important effect on the development of asthma in children than do outdoor pollutants (Etzel, 2003). Indoor air exposure is more strongly correlated with an increase in asthma prevalence (Etzel, 2003). Cigarette smoke, cockroaches, and aeroallergens are some
examples of indoor pollutants. Studies also show that indoor pollutants may also exacerbate asthma (Etzel, 2003). Children spend most of their time indoors. The following table shows the relationship between indoor exposures and asthma development and exacerbations (Etzel, 2003):

<table>
<thead>
<tr>
<th>Indoor Exposure</th>
<th>Asthma Development</th>
<th>Asthma Exacerbations</th>
</tr>
</thead>
<tbody>
<tr>
<td>House dust mite</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Environmental tobacco smoke</td>
<td>Probably Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Cockroach</td>
<td>Maybe increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Cat</td>
<td>Maybe increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Dog</td>
<td>Maybe increased</td>
<td>Probably Increased</td>
</tr>
<tr>
<td>Molds</td>
<td>?</td>
<td>Probably Increased</td>
</tr>
<tr>
<td>Oxides of nitrogen</td>
<td>?</td>
<td>Probably Increased</td>
</tr>
<tr>
<td>Ozone</td>
<td>?</td>
<td>Probably Increased</td>
</tr>
<tr>
<td>Particulates</td>
<td>?</td>
<td>Probably Increased</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>?</td>
<td>Probably Increased</td>
</tr>
</tbody>
</table>

Cigarette smoke is a big risk factor for the development of asthma in children (Etzel, 2003). There is a lot of evidence that a correlation between the two does exist, and there is evidence of a causal relationship as well (Etzel, 2003). Approximately 42% of infants (2 to 11 months) live with a smoker (Etzel, 2003). Murray found that children who have asthma and live in a home where there is a smoker have a significantly greater chance of having an asthma attack. His study has also shown that if an asthmatic child is exposed to a decrease in tobacco smoke than their symptoms will become less severe (Murray, 1993).

**Discussion**

What can be done to lower the level of pollution concentration in the environment? There were a series of federal legislative efforts to try and control air pollution beginning in the 1950s (Bernard et al., 2001). The Clean Air Act in 1970 set the National Ambient Air Quality Standards (NAAQS). Sections 108 and 109 of the Act
require the U.S. EPA to identify pollutants that "may reasonably be anticipated to endanger public health welfare" and to issue air quality criteria for them (Clean Air Act, 1970). The criteria must "accurately reflect the latest scientific knowledge" and are established by an independent scientific review panel, the Clean Air Scientific Advisory Committee (Clean Air Act, 1970). These standards are based on the air quality criteria (Bernard et al., 2001). The six criteria air pollutants are CO, lead, NO₂, O₃, PM, and SO₂. Ambient air concentration and emissions data about these pollutants have been collected nationwide for almost three decades (Bernard et al., 2001).

The Clean Air Act has been amended many different times. The U.S. EPA has to review the NAAQS every 5 years. Primary and secondary standards are set for the NAAQS. The primary standards are to protect the public health, which includes the health of populations high in the number asthmatics, children, and the elderly (Bernard et al., 2001). The secondary standards are to protect against welfare effects, which would include damage to animals, vegetation, and public facilities (Bernard et al. 2001). These standards can be set for either long term or short term averaging times or for both. The states usually enforce their own standards (Bernard et al., 2001).

Fossil fuel combustion processes can produce CO₂; other green-house gases produce criteria pollutant emissions as well (Bernard et al., 2001). Those policies that try and reduce greenhouse gas emission by reducing the demand for energy would be rewarded with a reduction of criteria pollutant emissions (Bernard et al., 2001). Research indicates that living near roads with a lot of automobile traffic is correlated with damaged respiratory health (D'Amato, 2002). A decrease in the number of vehicles would greatly increase the quality of air an individual breathes. De Marco et al. investigated the impact
of climate and long-term exposure to NO₂ on allergic rhinitis and asthma. He conducted a study on young adults living in 13 areas from two different Italian climatic regions (sub continental and Mediterranean). The Mediterranean areas had a significantly higher amount of asthma-like symptoms, higher annual mean temperature, lower temperature range and lower NO₂ levels than the sub continental ones. He also found that Mediterranean climate was associated with an increased risk of wheeze, tightness in the chest, shortness of breath asthma attacks. After he adjusted for climate, an increase of 18.3m³ in NO₂ levels he found moderate increase in the risk of asthma attacks, tightness in the chest and wheeze. When levels of NO₂ exposure rose, the prevalence of allergic rhinitis increased in the Mediterranean region, but not in the sub continental one. Finally, the climate interacting with NO₂ increased the risk for allergic rhinitis in subjects exposed to high stable temperatures. These results suggest that long-term exposure to traffic-related air pollution increases the risk of having asthma, while the positive association between the prevalence of allergic rhinitis and NO₂ detected only in the Mediterranean region may show that climate interacts with outdoor air pollution.

Air conditioning is another polluting condition humans have grown accustomed to using (Bernard et al., 2001). Humans have adapted over the years with ways to lessen their physical exertions. Air conditioning and the use of motor vehicles are just two examples of leisure. Although driving a car to work can save time and energy, it also increases the levels of pollution in the environment. Car pooling is one solution to this crisis. An example of indoor pollution is tobacco smoke. Many facilities are now forcing a no-smoking rule inside. These are just a few of the simple changes humans can make to help increase the quality of air in the atmosphere.
The United States has made efforts to reduce the amount of pollution in the air. In 1970 the introduction of the Clean Air Act came into effect. Since that time pollution from the combustion-related pollutants and other hazardous air pollutants have been under better control (Bernard et al., 2001). For example, the average lead emissions (especially from leaded fuels) have decreased 67% between 1988 and 1997 (Bernard et al., 2001). Previously facilities reported lead and lead compound emissions from manufacture or processing of more than 25,000 pounds annually. The reporting threshold now has been lowered to 100 pounds annually for each facility (Bernard et al., 2001). Although control measures have been introduced, air pollution is still a major concern. The U.S. Environmental Protection Agency (EPA) has been monitoring the pollutant concentrations over the past few decades. Data indicates that there is a decline in air pollution concentration; however, epidemiological studies reveal that morbidity and mortality rates associated with air pollution exposure still show a correlation (Bernard et al., 2001). De Marco's study is one example of why efforts need to be made to lower pollution levels in the environment. The correlational evidence from this study indicates that asthma can be exacerbated by environmental pollutants. Society is trying to adapt by forcing laws to clean up the environment (Bernard et al., 2001).

The Clean Air Act is also enforced to help control the hazardous air pollutants (HAPs). There are technology-based standards set for HAPs. The reduction of rain acid is an example of an important federal air pollution program. They are trying to reduce acid rain by controlling emissions of precursor pollutants (SO$_2$ and NO$_x$) from fossil fuel-fired power plants (Bernard et al., 2001).
Although the population, economy, and the use of on-road vehicles have increased since 1970, there has been a noticeable reduction in the criteria air pollutant emissions and ambient pollutant concentrations (Bernard et al., 2001). O₃ is the most resistant to efforts to reduce its concentration in the environment, however, once leaded gasoline was banned, the lead pollutant reduced dramatically (Bernard et al., 2001).

The declining rates of emissions and concentrations support the statement that the air quality in the U.S. has greatly increased since the 1970's. The air quality is still not perfect though. The air quality for many regions does not meet the NAAQS health standards (Bernard et al., 2001). In 1997, there were 52.6 million people living in areas that did not meet the air quality standards for any of the criteria pollutants (Bernard et al., 2001).

Conclusion

An increase in allergic respiratory diseases, seen more in urban areas than in rural areas, can be associated with an increase in atmospheric pollution concentration (D'Amato, 2003). There are many health risk associated with air pollutants. Evidence, such as the Lee et al. Taiwanese study, has found that exposure to environmental pollutants may increase a child's susceptibility of developing asthma. It may also increase the risk of asthma attacks (Etzel, 2003). The rates of asthma morbidity and mortality have increased 75% between 1980 and 1994 making research on this topic a major issue (Etzel, 2003).

Climate change may affect a person's exposure to air pollutants. It affects weather and local and regional pollution concentrations as well as affection anthropogenic emissions, and biogenic emissions. Temperature, precipitation, water
vapor, wind speed, and wind direction are all types of local weather patterns that can affect atmospheric chemical reactions (Bernard et al., 2001). Because weather is also associated with energy demands, it may be able to change patterns of fossil fuel combustion (Bernard et al., 2001).

Children are exceptionally vulnerable to the pollution in the environment. Reports on asthma have doubled within the past two decades (Woolcock, 1997). Outdoor pollutants are more likely the cause of asthma exacerbations, whereas indoor pollutants are more likely the cause for the onset of asthma within a child (Etzel, 2003).

Cultural, social, and physical adaptations need to be made in order to cope with the polluted environment. Changes in transportation, farming, and industrialization could help decrease the amount of pollution concentration in the atmosphere. Although the government has increased efforts to fight pollution such at the Clean Air Act of 1970, air pollution is still a major problem and may not be taken lightly.
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