The Public Health Impact of Air Pollution in New Jersey

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Table of Contents

EXECUTIVE SUMMARY

Air pollution takes a significant toll on human health in New Jersey every year, shortening thousands of lives and sending thousands of people to area hospitals.

Premature death and hospital admissions are the most visible indicators of widespread health damage caused by air pollution. This damage manifests itself in the incidence of disease like chronic bronchitis, increased emergency room visits, more frequent asthma attacks, and missed work days due to respiratory illness in otherwise healthy people. At the root of all of these health problems lies irreparable damage to lung tissues not unlike that caused by second-hand tobacco smoke.

This study calculates the magnitude of air pollution's impact on health in New Jersey using a number of information sources: air pollution monitoring data from the U.S. Environmental Protection Agency (EPA); baseline health statistics from the New Jersey Department of Health and Senior Services and the U.S. EPA; a review of scientific studies on air pollution and health; and methodology based on similar work from the U.S. EPA and the World Health Organization.

These sources, taken together, indicate that thousands of New Jersey residents die prematurely because of soot in the air, and hundreds of thousands miss work because of air-pollution induced respiratory illness (see Table 1).

Additionally, during the summer smog season, smog causes chronic asthma in thousands of New Jersey adults, hundreds of thousands of asthma attacks, and millions of days of increased respiratory symptoms like shortness of breath (see Table 2).

Children are especially vulnerable to the effects of air pollution. Every year, particulates cause dozens of neonatal deaths and in the range of half-a-million school absences from illness (see Table 9).

Many New Jersey residents appear to experience adverse effects from pollution levels that comply with "health-based" air pollution standards. This leads to the jarring conclusion that even "safe" levels of pollution are not, in fact, safe.

Aggressive action on both the state and federal level to reduce air pollution can improve public health. In order to have the greatest impact, action should focus first on the largest sources of pollution. Within New Jersey in 1999, nearly 60% of soot emissions and almost half of smog-forming emissions came from on-road and off-road mobile sources like

Table 1: Annual Public Health Damage from Fine Soot (PM 10) in New Jersey

Health Effect	Number of Cases
Premature Mortality (age 30 +)	2,300 to 5,400
Respiratory Hospital Admissions	5,100 to 7,800
Cardiovascular Hospital Admissions	2,700 to 7,500
New Cases of Chronic Bronchitis	450 to 9,500
Missed Work Days	460,000 to 530,000
Asthma Attacks	330,000 to 1.4 million
Restricted Activity Days	7.1 million to 9.7 million
Increased Symptom Days	14 million to 45 million

cars, trucks, and construction equipment. Industrial facilities and emissions from consumer products like paint accounted for the remainder. Out-of-state pollution sources also contribute significantly to the overall problem.

State Level Actions:

- Strengthen auto emission standards in line with New York, Massachusetts, California, and Vermont.
- Reduce car-dependent land use practices and sprawl.
- Increase the portion of state transportation funding for transit, rail freight, and other alternative transportation projects.
- Require diesel engines, including school bus fleets and construction equipment, to be retrofitted with particulate filtration systems and to use low-sulfur fuel.
- Require diesel engines in marine vessels and trains to have selective catalytic reduction systems.

Federal and Regional Level Actions:

- Advocate adoption of these state policies among neighboring and upwind states.
- Restore the New Source Review provision of the Clean Air Act and require the oldest coal-fired power plants and other industrial facilities in the country to install modern emissions control technology.
- Limit nationwide industrial emissions of sulfur dioxide, nitrogen oxides, and mercury to between 10% and 30% of 2000 levels.
- Strengthen national emission standards for cars, trucks, and off-road vehicles, including incentives for manufacturers to produce cleaner vehicles, modeled after California state policy.

Table 2: Annual Public Health Damage from Smog (Ground-Level Ozone) in New Jersey

Health Effect	Number of Cases
Adult Onset Asthma	860 to 1,900
Respiratory Hospital Admissions	3,900 to 5,900
Asthma ER Visits	640 to 12,000
Asthma Attacks	110,000 to 310,000
Restricted Activity Days	960,000 to 1.7 million
Increased Symptom Days	2.4 million to 7.5 million

Table 9: Annual Damage to Children's Health from Air Pollution in New Jersey

Health Effect	Number of Cases
Infant Mortality	40 to 80
Asthma Hospitalizations	290 to 440
Asthma ER Visits	190 to 3,400
Acute Bronchitis	21,000 to 77,000
Asthma Attacks	150,000 to 170,000
Missed School Days	Roughly 610,000

INTRODUCTION

Respiratory health was never a big concern for Margaret Manzi before she and her family moved to Moorestown, N.J. from Michigan in 1997 – other than the occasional cold. Over the last six years, however, that has changed. "My older child has had a troubling number of missed school days," said Manzi. "He sometimes seems to have difficulty inhaling fully, which hurts his endurance in sports, not to mention how it alarms me."

Sandra Weissfisch lives in Ridgewood with her 18-year-old son, who recently developed asthma. Sandra believes this is a direct result of the air pollution in the Northern New Jersey area.

In 2002, Katherine Watt fled from the pollution on Staten Island to Plainfield, where she now lives with her family. Since moving to New Jersey, she has had to take her five-year-old son to the emergency room twice for severe asthma symptoms.

Jim Hala lives in Morristown, and suffers from asthma. Before he moved to New Jersey, he did not need asthma medication. Now he has three inhalers: two for prevention and one for onset. "People such as me are New Jersey's coal mine canaries," said Hala. "We are letting you know that there is something wrong with New Jersey's air."

These stories are not unique. Air pollution-triggered deaths, hospital admissions, emergency room visits, and asthma attacks are merely the most visible signs of the adverse health effects that threaten everyone who breathes polluted air. All of us face an increased risk of long-term respiratory damage and reduced overall daily health due to the dangerous pollutants in New Jersey's air.

Nor are we safe on days when air pollution levels are below those recognized by government as "safe." Ozone smog and particulate soot can affect health even on days when an air pollution alert is not in effect.

It wasn't supposed to be this way – not in 2003. When Congress adopted the federal Clean Air Act in 1970, it established the goal of setting and achieving air quality standards protective of human health by 1975. Nearly three decades later, New Jersey's air still frequently fails to meet established health standards – standards that may not be fully protective of human health.

With efforts underway to roll back key air pollution policies at the federal level – and with increased motor vehicle traffic, population, and overall energy use threatening to undermine the progress we have made toward cleaner air – New Jersey has reached a critical juncture. Solutions do exist. From modern emission controls for cars and power plants to effective transit systems, we have the technological know-how to significantly cut the amounts of air pollution in New Jersey air.

By adopting public policies that put these technologies to work, New Jersey can reduce air pollution, and help millions of its citizens to live longer and healthier lives.

Background: Exposure to Air Pollution and How it Causes Harm

Most people think of air pollution only on days when the evening newscast announces an "Ozone Action Day" because the haze levels will be especially high. Unfortunately, people in New Jersey aren't exposed to air pollution just a few dozen times a year on bad air days. New Jerseyans breathe air pollution day in and day out throughout their entire lives.

Much of the pollution comes from burning fossil fuels for energy – in cars, trucks, power plants, industrial facilities, and engines. These pollutants are invisible, and they are everywhere. They mix together in the atmosphere and react in complicated ways to form a toxic soup.

On bad air days, visibility plummets and the air looks thick and hazy (Figure 1). Sometimes the sun even looks red as it sets due to pollutants in the air. These clouds of haze contain hundreds of toxic chemicals.

Two of the most harmful air pollutants are smog and fine soot. Smog plagues summer days in New Jersey when intense sunlight transforms air pollutants and oxygen into a toxic gas called ozone. Fine soot, or particulate pollution, contaminates the air year round, either directly emitted by power plants and motor vehicles or resulting from chemical reactions in the air.

Smog and fine soot reach unhealthy levels regularly in New Jersey. Annual average soot concentrations in New Jersey range from about 15 micrograms per cubic meter in the least polluted parts of the state to 38 micrograms per cubic meter in the most polluted parts of the state. These levels are technically in compliance with EPA health standards, but still cause health problems. During the summertime ozone season from April through October, the average daily peak one-hour ozone levels reach 47-64 ppb across the state (Figure 2). On hot summer days, ozone levels routinely exceed EPA health standards.

If there were no human-induced air pollution emitted in North America, soot levels would be around 5 micrograms per cubic meter, and smog levels would be about 20 ppb.[2] If pollution were not emitted from other countries in the world

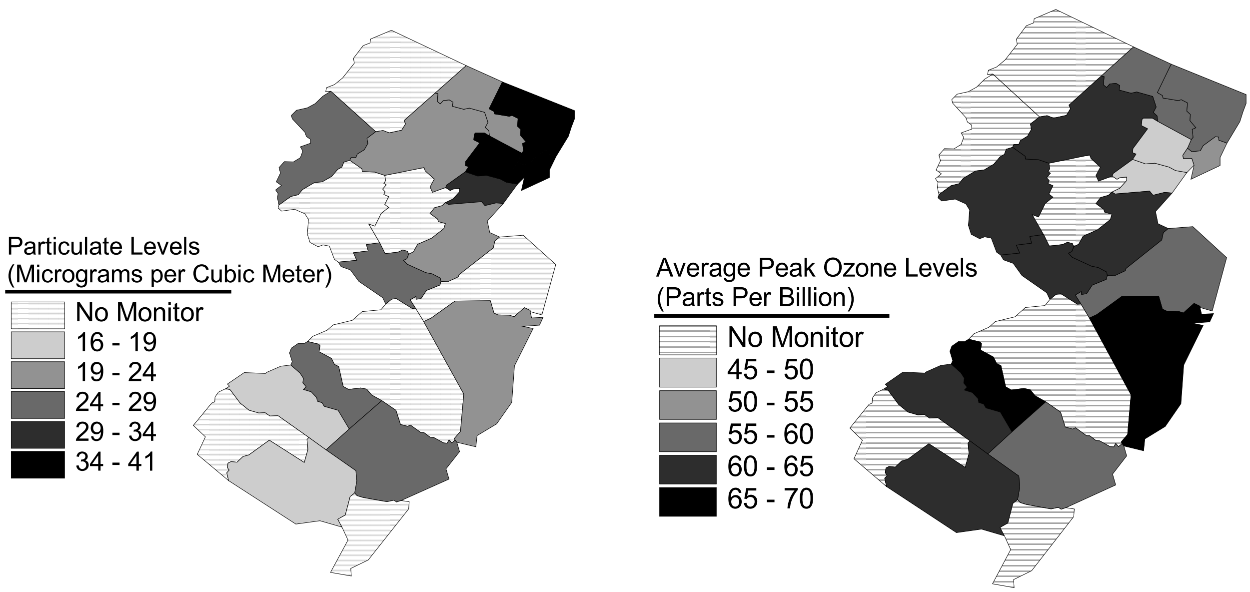
Figure 1: Clear and Polluted Days in Newark

A relatively clear day in Newark.

Polluted skies over Newark.

NESCAUM, CAMNET: Real Time Air Pollution and Visibility Monitoring Network

Figure 2: Soot and Smog Levels in New Jersey[1]



Annual average particulate levels in New Jersey.

Average daily peak ozone levels from April through October.

as well, these natural background levels would be even lower.[3]

Fine soot and smog cause damage when they come in contact with lungs. Ozone quickly reacts with airway tissues and produces an inflammation similar to a sunburn on the inside of the lungs. Particulates travel deep into the lower passages of the lungs and become trapped there, delivering a payload of toxic chemicals. Constant exposure to these pollutants over time produces permanent damage to lung tissues, decreases the ability to breathe normally, and exacerbates or even causes chronic disease.

Smog (Ground-Level Ozone)

Smog plagues summer days in New Jersey. Smog results when a mixture of pollutants mainly from fossil fuel combustion react under intense sunlight to form ozone. Although this pollutant reaches levels that violate the U.S. EPA health standard on about one of every three summer days, it chronically contaminates the air at lower, but still harmful, levels from April through October.[6]

Ozone is a powerful chemical gas sometimes used to kill bacteria in drinking water. Bubbling it through contaminated water shreds any infectious organisms in the water and makes it safe to drink. Not surprisingly, the chemical has the same effect on our lungs – when inhaled, it burns through lung tissue and causes short-term swelling. With long-term exposure at even low levels, it causes permanent and irrevocable damage.

Scientists have known for well over a decade that ozone at levels routinely encountered in New Jersey burns cells, causes reddening and swelling, and re-

National Air Quality Standards: Why They Are Too Weak

The Environmental Protection Agency (EPA) sets national air quality standards under the authority of the federal Clean Air Act. The standards are meant to be set based on our best knowledge of what will protect public health. In that spirit, the EPA tightened standards for both soot and smog in 1997, based on new research coming out at the time that showed that soot and smog were more harmful than previously believed.

However, strengthening standards is a process fraught with political difficulty. For instance, the American Trucking Association led a coalition of industries in a lawsuit against the new standards, taking it all the way to the Supreme Court in 2001.[4] The high court eventually rejected the industry arguments, but the process delayed implementation of the new standards for years.

Political difficulty affects how EPA implements the standards as well. In June 2003, EPA proposed implementation plans for the new smog standards that would actually weaken public health protection.[5] The EPA proposal would give polluted metropolitan areas more time and more loopholes to avoid necessary action to clean the air. For example, the plan would give the northern New Jersey and New York region, which has not yet met the standard set in the 1990 amendments to the Clean Air Act, a new classification under the new standard and yet another extension of time to clean-up its air. The old deadline for compliance would disappear entirely, along with already-adopted pollution control limits on highway-related transportation emissions, opening the door to indiscriminant road-building.

duces the elasticity of lung tissues over time.[7] Ozone makes lung tissues more sensitive to allergens and less able to ward off infections.[8] It scars airway tissues. Children exposed to ozone develop lungs with less flexibility and capacity than normal. During high smog days, otherwise healthy people who exercise can't breathe normally.[9]

New scientific evidence continues to show dramatic evidence of the severe and long-term impact ozone exposure has on respiratory health:

- College freshmen who were raised in less polluted areas have lungs that work better than their schoolmates who grew up in polluted cities. For example, UC Berkeley freshmen from the relatively clean San Francisco Bay area can exhale more forcefully than students from the polluted Los Angeles area.[10] Yale freshmen who had lived for four or more years in a county with high ozone levels can't breathe as well as freshmen from cleaner areas.[11]

- Recent studies show that the lungs of asthmatic infant rhesus monkeys suffer irreversible structural damage when exposed to ozone.[12] Ozone exposure reduces the number of branches formed by nerves and airway passages in the lung and forces lung muscles to reorganize, and long recovery periods do not improve the damage. The immune system and cellular responses to ozone are like those seen with asthma. Dr. Charles Plopper of the University of California at Davis, the author of the studies, commented, "from a public health standpoint, it's a pretty disquieting situation."[13] Researchers believe the same damage happens to human infants.
- Striking new results from the ambitious Southern California Children's Study indicate that exposure to ozone can cause asthma in children.[14] Children who exercise frequently in smoggy areas are more than three times as likely to develop asthma as those in cleaner parts of the country.

Taken together, these studies paint a picture of profound and irreversible respiratory damage beginning with an infants' first breath of ozone-tainted air, leading to impaired lung development and chronic respiratory disease.

Fine Soot (Particulate Matter - PM10)

Back in the early days of the industrial revolution, thick black smoke poured from factories and coal-fired furnaces. During the 1952 "Great Fog," perhaps the most famously devastating single pollution event in history, 12,000 Londoners died from intense pollution exposure.[15]

Today, the thick, black smoke characteristic of uncontrolled pollution has been replaced with the more subtle and insidious dirty haze that can look almost natural because of its frequent presence over the eastern United States. However, this pollution is anything but natural. It comes from fuel burning, and mostly consists of fine soot, or extremely small and practically invisible particles in the air.

Some types of soot are simply unburnt fuel particles. Other types of soot are created when pollutants react with each other in the atmosphere. Particles can contain hundreds of different chemicals from cancer-causing agents like polycyclic aromatic hydrocarbons to metals from arsenic to zinc.

Forty to 1,000 times smaller than the width of a human hair, these superfine particles result from burning fossil fuels like coal, gasoline, and diesel. For example, burning a pound of jet fuel creates 100 quadrillion particles.[16] Gasoline and diesel engines with and without catalytic converters emit particles with a consistent size of 0.1 to 1 micrometers, with the smallest particles coming from gasoline and medium-duty diesel engines.[17] Scientists often measure fine particles in the air by trapping particles smaller than 10 micrometers (PM 10) or particles smaller than 2.5 micrometers (PM 2.5).

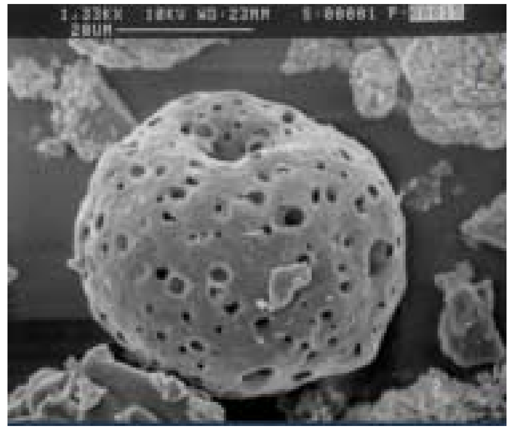
Fine particles can remain suspended in the air for weeks. They can travel through building shells and conventional heating and air conditioning filters. When inhaled, they are able to penetrate deep into the lung where they deliver their toxic payload. In contrast, larger particles such as dust or pollen travel shorter distances and are more effectively trapped in the upper airway.

Fine particles penetrate to the deepest part of the lung, where they are attacked and absorbed by immune cells. In an study in England, ultra fine carbon particles showed up in the immune cells of every child tested – even in a three-month old infant.[18] The particles were of the same size emitted by motor vehicles, and children who lived close to busy roads had up to three times more particles in their bodies.

Some of the particles remain trapped in the lung, while others travel through the blood to the rest of the body.[19] Scientists have counted particulates in the lung tissue of cadavers. People from highly polluted Mexico City had two billion particles in every gram of lung tissue, and people from less polluted Vancouver, Canada had about 280 million.[20]

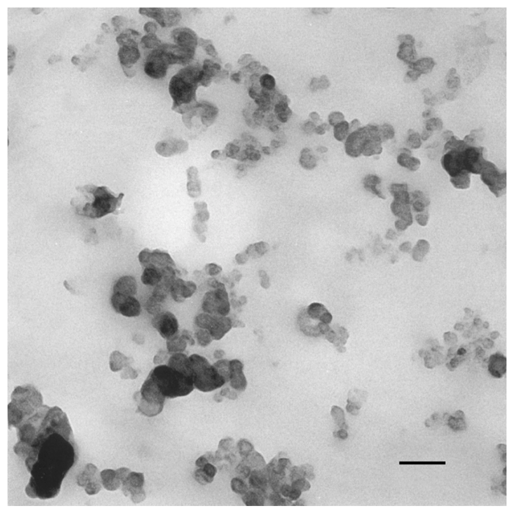
The chemicals delivered into the body by inhaled particulates are very dangerous. Some of them cause cancer, some cause irritation to lung tissues, and some cause changes in the function of the heart.[21] As a result, particulates cause a host of health problems, including lung cancer and cardio-respiratory disease.

Upwards of 50,000 Americans die every year because of particulate pollution. In fact, according to the largest study of the effects of particulates on mortality, breathing the air in particulate-polluted areas is about as dangerous as living or working with a smoker.[22]



Dr. Heather Viles, Oxford University

A soot particle created by burning oil seen through an electron microscope. Air pollution particles from automobile and diesel fuel are much smaller, in the range of 0.1 micrometers.



J. Grigg, "The Health Effects of Fossil Fuel Derived Particles," Archives of Disease in Childhood 86: 79-83, 2002

Fine soot particles found in diesel exhaust. The scale bar represents 10 nm.

Other Toxic Pollutants in New Jersey's Air

Burning coal, oil, gas, and diesel fuel creates pollutants beyond soot and smog that also harm respiratory health. For example, cars and trucks emit chemicals like benzene, formaldehyde, acetaldehyde, and 1,3-butadiene.

- A study of Hispanic children showed that in addition to soot and smog, other toxic chemicals such as benzene, formaldehyde, acetaldehyde, and 1,3-butadiene can aggravate asthma symptoms.[23]
- Workplace exposure to formaldehyde can cause asthma.[24]
- Benzene and formaldehyde also cause leukemia and other types of cancers.[25]

Table 1: Annual Public Health Damage from Fine Soot (PM 10) in New Jersey

Health Effect	Number of Cases
Premature Mortality (age 30 +)	2,300 to 5,400
Respiratory Hospital Admissions	5,100 to 7,800
Cardiovascular Hospital Admissions	2,700 to 7,500
New Cases of Chronic Bronchitis	450 to 9,500
Missed Work Days	460,000 to 530,000
Asthma Attacks	330,000 to 1.4 million
Restricted Activity Days	7.1 million to 9.7 million
Increased Symptom Days	14 million to 45 million

Table 2: Annual Public Health Damage from Smog (Ground-Level Ozone) in New Jersey

Health Effect	Number of Cases
Adult Onset Asthma	860 to 1,900
Respiratory Hospital Admissions	3,900 to 5,900
Asthma ER Visits	640 to 12,000
Asthma Attacks	110,000 to 310,000
Restricted Activity Days	960,000 to 1.7 million
Increased Symptom Days	2.4 million to 7.5 million

RESULTS: HEALTH DAMAGE CAUSED BY AIR POLLUTION IN NEW JERSEY

Health researchers have just begun to map out the consequences of breathing polluted air, and the results aren't pretty. The most serious impacts include premature death from diseases like cancer and heart disease, respiratory deaths in infants, and new cases of persistent diseases like chronic bronchitis and asthma.

These are just the most visible indicators of widespread health damage that impacts everyone in the state. This widespread damage manifests itself in increased emergency room visits, more frequent asthma attacks, and even missed work days due to respiratory illness in otherwise healthy people. And at the root of all of these health problems lie chronic damage to lung tissues not unlike that caused by tobacco smoke.

To quantify the health impacts of air pollution, three basic pieces of information are required:

- The exposure of people to air pollutants,
- How the frequency and risk of a given health impact changes with increasing or decreasing air pollution levels, and
- The baseline frequency of a given health problem in society.

Air pollution monitors placed throughout New Jersey by the Department of Environmental Protection help provide the first piece of information. A vast body of scientific literature in which researchers tracked pollution and health effects provides the second piece of information. And the third comes from health statistics maintained by the New Jersey Department of Health and Senior Services, plus additional information from surveys and studies in the scientific literature.

Using this information, we estimate that every year in New Jersey, thousands die prematurely because of soot in the air, thousands are admitted to area hospitals with air-pollution aggravated heart and lung disease, and hundreds of thousands miss work because of air-pollution induced respiratory illness (see Table 1).

Additionally, during the summer smog season, we estimate that smog causes chronic asthma in thousands of New Jersey adults, hundreds of thousands of asthma attacks, and millions of days of increased respiratory symptoms like shortness of breath (see Table 2).

Premature Death

The most serious health impact of exposure to air pollution is premature death from respiratory disease, heart disease, lung cancer, and other types of diseases commonly associated with smoking. The evidence linking fine particulate levels to both long-term and acute increases in the risk of death is very compelling.

The Evidence

Several decade-long studies have made it quite clear that long-term exposure to pollution shortens lives:

- In 2002, Dr. C. Arden Pope at Brigham Young University and his colleagues published a study tracking over 500,000 people in 51 metropolitan areas in America for over 16 years. He found that when PM10 levels increased by 10 micrograms per cubic meter, deaths from all causes rose by 4%; deaths from cardiopulmonary illness by 6%; and deaths from lung cancer by 8%.[27] Dr. Pope saw no evidence

Table 3: Annual Premature Deaths Caused by Air Pollution in New Jersey

Health Effect	Number of Cases
Premature Mortality (age 30 +)	2,300 to 5,400

for a safe level of particulate pollution not tied to increased death rates. He concluded that breathing polluted air like that commonly found in the eastern U.S. causes an increased risk of lung cancer similar to that of breathing secondhand smoke.[28]

- Researchers with the World Health Organization in Europe found that air pollution caused 6% of all deaths in Switzerland, France, and Austria (40,000 per year). Motor vehicle pollution caused about half of these deaths.[29]

Dozens of studies also link short-term exposure to pollution to acute increases in the death rate:

- In a study of heart attack patients in Boston, Dr. Annette Peters and her colleagues at the Harvard University School of Public Health found that as pollution levels rose, so did the frequency of heart attacks a few hours to a day later.[30] An increase in fine particles of 25 micrograms per cubic meter resulted in a 69% increase in the relative risk of having a heart attack over the following day.
- Dr. Jonathan Samet from Johns Hopkins University's Bloomberg School of Public Health and his colleagues studied health and air pollution data from 90 cities in the U.S. and found a link between pollution levels and acute death rates from chronic heart and lung disease. The link was strongest in the Northeast, the industrial Midwest, and in Southern California.[31]

Pollution associated with burning fossil fuels, as opposed to small particles from dust-storms and other natural events, is specifically tied to increased mortality.[32] Other studies show that these effects are not merely accelerating the death of old and sickly adults on the brink of death, but also kill some infants and adults who otherwise would have many years of health remaining.[33]

New Jersey Estimate

We estimate that soot pollution causes 2,300 to 5,400 deaths each year in New Jersey, or 5.4% to 7.7% of all non-injury- or accident-related deaths. This estimate is on par with the World Health Organization study of air pollution impacts, which reported 6% of all mortality in Switzerland, France, and Austria is linked to air pollution.[34]

Hospital Stays

As levels of air pollution increase, so do the number of people admitted into hospital wards suffering from severe respiratory and cardiovascular disease.

The Evidence

- Dr. Jonathan Samet from Johns Hopkins University's Bloomberg School of Public Health and his colleagues found that increases in daily pollution levels were linked to increased hospital admissions for cardiovascular disease, pneumonia, and chronic obstructive pulmonary disorder.[35]
- Dr. Joel Schwartz of Harvard University and his colleagues documented links between ozone and hospitalization rates for cardiovascular and respiratory disease in Birmingham, Detroit, Minneapolis-St. Paul, and Tucson.[36] An increase of soot levels by 100 micrograms per cubic meter and ozone by 50 parts per billion increased the risk of hospitalization for chronic respiratory disease in the range of 20% to 100%.
- Dr. George Thurston at the New York University School of Medicine and Dr. Richard Burnett at Environment Canada have repeatedly linked respiratory and cardiovascular hospital admissions with the levels of summertime haze air pollution.[37] According to these studies, summertime haze pollution was responsible for 24% of respiratory hospital admissions in Toronto, and up to half of admissions on particularly bad air days.

How We Estimated The Health Effects of Air Pollution

In November 1999, the EPA released a report outlining the health and economic impact of clean air efforts. In addition, scientists with the World Health Organization produced a report in 2000 estimating the public health impact of particulate air pollution from motor vehicles.[26]

NJPIRG researchers adapted the methodology developed by these experts to estimate the health effects of air pollution in New Jersey. First, we gathered statistics on the baseline frequency of health events like deaths, hospital admissions, and asthma attacks. Second, we looked at monitoring data for air pollution in the state to estimate how much pollution people are exposed to. Finally, we estimated the fraction of the baseline health problems in the state that could be attributed to air pollution. This step involved applying the relationship between air pollution and the frequency of health effects as observed by epidemiologists and published in scientific literature to estimate how many deaths, hospital admissions, etc. would be avoided if air pollution levels returned to natural background levels.

We report the effects of air pollution as a range of values to emphasize the inherent uncertainty present in such an estimate. The range represents the 90% confidence interval derived by scientists for the relationship between air pollution and the frequency of health outcomes, or where the estimate would be expected to fall 90 times out of 100 observations. The range of values presented here are our best estimate of the public health toll of air pollution in New Jersey. For more details, see the Methodology section.

Table 4: Annual Hospital Admissions Caused by Air Pollution in New Jersey

Health Effect	Number of Cases
Respiratory Hospital Admissions (Soot)	5,100 to 7,800
Cardiovascular Hospital Admissions (Soot)	2,700 to 7,500
Respiratory Hospital Admissions (Ozone)	3,900 to 5,900

New Jersey Estimate

We estimate that soot pollution causes 5,100 to 7,800 respiratory and 2,700 to 7,500 cardiovascular hospital admissions each year, and smog causes 3,900 to 5,900 respiratory hospital admissions during the summer smog season. This represents 3.8% to 4.5% of respiratory hospital admissions (soot), 1.8% to 2.5% of cardiovascular hospital admissions (soot), and 2.7% to 3.3% of respiratory hospital admissions (ozone).

New Cases of Chronic Disease – Asthma and Bronchitis

Air pollution causes chronic diseases in addition to short-term damage. From new cases of chronic asthma in otherwise healthy children and adults to the development of chronic bronchitis in elderly people, these are severe diseases that cause significant distress for hundreds of thousands of New Jersey residents.

The Evidence

- Dr. Rob McConnell at the University of Southern California School of Medicine and his colleagues found that children who exercise a lot develop asthma at higher rates in more polluted areas. The researchers followed for five years over 3,500 children from the fourth, seventh, and tenth grades with no history of asthma. During that time, 265 became asthmatic. Children who played three or more sports in communities with high smog levels developed asthma at over three times the rate of children in low-smog communities. Children who spent relatively high amounts of time outdoors were 1.4 times more likely to get asthma in polluted areas compared to cleaner ones.[38] The levels of air pollution in all of the communities examined were well below the U.S. EPA health standard of 80 ppb over an eight hour period.
- Dr. William McDonnell at the U.S. EPA National Health and Environmental Effects Research Laboratory and his colleagues found a connection between long-term exposure to smog and development of asthma in adults. The researchers followed over 3,000 non-smoking adults for 15 years in California. During this period, just over 3% of the men and just over 4% of the women reported a diagnosis of asthma. Several factors increased the risk of developing asthma, including: history of exposure to tobacco smoke, childhood pneumonia or bronchitis; and exposure to ozone in men.[39]
- In Taiwan, researchers linked development of asthma with several individual air pollutants: fine soot, sulfur dioxide, nitrogen dioxide, and carbon monoxide. The scientists surveyed

Table 5: Annual New Cases of Chronic Respiratory Disease Caused by Air Pollution in New Jersey

Health Effect	Number of Cases
New Cases of Chronic Bronchitis (Soot)	450 to 9,500
Adult Onset Asthma (Ozone)	860 to 1,900

over 160,000 schoolchildren and looked at levels of air pollutants, finding that air pollution increased asthma prevalence by as much as 29%, independently of exposure to second-hand tobacco smoke.[40] Similar research in Hong Kong showed that children living in areas with higher air pollution had higher levels of asthma and less healthy lungs.[41]

- Dr. Joel Schwartz and others identified links between particulate levels and physician diagnoses of chronic bronchitis by looking at health records and air pollution levels in 53 U.S. metropolitan areas.[42] For every 10 microgram per cubic meter increase in total particulates, the relative risk for chronic bronchitis rose about 7%.

Asthma prevalence is increasing in the U.S. and worldwide, for unknown reasons. In the US, the Centers for Disease Control and Prevention (CDC) estimates that prevalence among persons up to 17 years old increased about 5% per year from 1980 to 1995.[43] Deaths due to asthma have doubled, and now amount to 5,000 per year.[44] The trend in the number of children with active asthma in New Jersey also has been increasing over the past few decades. According to a survey carried out by the CDC in 2001, 12.6% of all children in America had been diagnosed with asthma at one point in their lives, and 5.7% had an asthma attack in the last year.[45] According to the more recent Behavioral Risk Factor Surveillance Survey carried out by the CDC in 2002, 11.8% of New Jersey adults have been diagnosed with asthma.[46]

New Jersey Estimate

We estimate that air pollution causes 450 to 9,500 new cases of chronic bronchitis and 860 to 1,900 cases of adult onset asthma among New Jersey residents every year. Because ozone exposure was only linked to asthma development in males in the McDonnell paper cited above, our estimate only considers new cases of asthma in the adult male part of the population.

Emergency Room Visits

Studies from New Jersey and across the country confirm that as air pollution levels rise, increasing numbers of children and adults seek emergency medical attention for respiratory problems.

The Evidence

- Dr. Paul Lioy and his colleagues at the Rutgers Environmental and Occupational Health Sciences Institute and UMDNJ – Robert Wood Johnson Medical School saw increases in the number of asthma emergency room visits in central and northern New Jersey on high-smog summer days.[47]

Table 6: Annual Emergency Room Visits for Respiratory Ailments Caused by Air Pollution in New Jersey

Health Effect	Number of Cases
Asthma ER Visits (Ozone)	640 to 12,000

Emergency room visits occurred 28% more frequently when the average ozone levels were greater than 60 ppb than when they were lower. This study demonstrates health effects of ozone exposure well below the EPA health standard of 80 ppb over an 8 hour period.

- Dr. Joel Schwartz from Harvard University and his colleagues at the U.S. EPA found that as fine soot levels increased in the Seattle area, so did emergency room visits for asthma.[48] An increase in fine soot levels of 30 micrograms per cubic meter increased the relative risk of needing emergency medical attention for asthma by 12%. The daily fine soot levels never exceeded 70% of the EPA health standard at the time.

New Jersey Estimate

We estimate that air pollution causes 640 to 12,000 emergency room visits for treatment of asthma among New Jersey residents every year, or between 3% and 60% of summer asthma emergency room visits.

Asthma Attacks

When pollution levels rise, so do the frequency of asthma attacks suffered by asthmatic children and adults.

The Evidence

- Dr. George Thurston and his colleagues at the New York University School of Medicine documented increased asthma attacks, respiratory difficulty, and reduced lung function in children on high pollution days.[49] The researchers tracked children attending the American Lung Association's Connecticut "Asthma Camp" during summer months. On the highest pollution days, the risk of asthma attacks requiring medication and chest tightness climbed 40% higher than usual.
- In the mid 1970s, the Environmental Protection Agency collected asthma attack diaries from Los Angeles residents. Asthma attacks were reported more frequently when smog and soot levels were high, as well as when the weather was cool.[50]

Table 7: Annual Asthma Attacks Triggered by Air Pollution in New Jersey

Health Effect	Number of Cases
Asthma Attacks (Soot)	330,000 to 1.4 million
Asthma Attacks (Ozone)	110,000 to 310,000

Table 8: Annual Missed Work Days and Increased Respiratory Symptom Days Caused by Air Pollution in New Jersey

Health Effect	Number of Cases
Missed Work Days (Soot)	460,000 to 530,000
Restricted Activity Days (Soot)	7.1 million to 9.7 million
Increased Symptom Days (Soot)	14 million to 45 million
Restricted Activity Days (Ozone)	960,000 to 1.7 million
Increased Symptom Days (Ozone)	2.4 million to 7.5 million

New Jersey Estimate

We estimate that soot pollution causes 330,000 to 1.4 million asthma attacks and smog pollution causes 110,000 to 310,000 asthma attacks among New Jersey asthmatics every year.

Missed Work Days and Increased Sick Days

In addition to harming asthmatic individuals, air pollution can affect the health of people with no chronic respiratory illness. On high pollution days, the number of people feeling ill with problems like shortness of breath, runny or stuffy noses, coughs, burning eyes, wheezing, and chest pain increases dramatically. These symptoms can cause people to miss work or school, or force them to limit their usual activity levels.

The Evidence

- Dr. Bart Ostro at the California EPA linked high air pollution levels with missed work days and illness days reported in the Health Interview Survey collected yearly by the U.S. Centers for Disease Control and Prevention.[51]
- Dr. Joel Schwartz of Harvard and his colleagues found that elementary school children in six U.S. cities suffered from coughs and other lower respiratory symptoms more often on days when soot and smog levels were high.[52]

New Jersey Estimate

We estimate that soot pollution causes 460,000 to 530,000 missed work days, 7.1 million to 9.7 million person-days when illness limits normal activity levels, and 14 million to 45 million person days with the presence of at least one of a variety of respiratory symptoms like shortness of breath, runny or stuffy noses, coughs, burning eyes, wheezing, and chest pain. In addition, we estimate that smog causes 960,000 to 1.7 million person-days when air pollution limits normal activity and 2.4 million to 7.5 million person days with respiratory symptoms.

Table 9: Air Pollution Damage to Children's Health in New Jersey

Health Effect	Number of Cases
Infant Mortality	40 to 80
Asthma Hospitalizations	290 to 440
Asthma ER Visits	190 to 3,400
Acute Bronchitis	21,000 to 77,000
Asthma Attacks	150,000 to 170,000
Missed School Days	Roughly 610,000

Automobile exhaust -- a source of smog and very fine soot.

Air Pollution and New Jersey's Children

Children are especially vulnerable to the effects of air pollution. First, children are developing into adults. Their lungs are growing. Injuries sustained during this time can cause permanent damage that will have life-long effects. Second, children breathe more air per pound of body weight, thus getting higher doses of pollutants.

Children in New Jersey are constantly exposed to air pollution, breathing it day in and day out. Recent science has shown that this exposure causes a range of lung injuries, even among otherwise healthy infants and children. Children exposed to air pollution can't breathe as well as children growing up in cleaner areas. Their lungs are scarred and less flexible than they should be, their lungs hold less air, and they aren't as able to breathe normally. These injuries manifest themselves in respiratory illness, missed school days, increased doctor visits, hospitalizations, and for a small group, death.

NJPIRG researchers compiled air pollution data, scientific reports about how air pollution levels affect children's health, and baseline health statistics maintained by the state Department of Health and Senior Services and the EPA. We used this information to estimate the health impacts of pollution on children in New Jersey (for more details, see the Methodology section).

We estimate that air pollution kills several dozen infants a year and causes several hundred asthma hospitalizations in children, several thousand emergency room visits for childhood asthma, tens of thousands of cases of acute bronchitis, over a hundred thousand asthma attacks, and in the range of half-a-million missed school days (Table 9).

Infant Death

Air pollution not only kills elderly and sick people. It also causes premature death in infants and young children. Studies have tied particulate levels to deaths both from respiratory disease and from sudden infant death syndrome.

The Evidence

- Dr. Tracey Woodruff at the U.S. EPA and her colleagues linked fine soot pollution levels and neonatal deaths in 86 U.S. metropolitan areas.[53] Normal-weight infants less than one year old born in high soot areas were 40% more likely to die of respiratory disease, and 26% more likely to die from sudden infant death syndrome than infants born in low soot areas.
- Researchers in the Czech Republic found that newborn deaths due to respiratory causes were linked to in-

Table 10: Annual Infant Deaths from Air Pollution in New Jersey

Health Effect	Number of Cases
Neonatal Mortality	40 to 80

creased levels of fine soot, sulfur dioxide, and oxides of nitrogen.[54] The study concluded, "the effects of air pollution on infant mortality are specific for respiratory causes in [the period between one month and one year of age], are independent of socioeconomic factors, and are not mediated by birth weight or gestational age."

- The National Bureau of Economic Research found that as levels of particles fell during a recession in the early 1980s, so did rates of death in newborn children younger than 28 days old. Specifically in Pennsylvania, researchers found that when total fine particulate levels dropped 25%, newborn death rates from cardiopulmonary and respiratory causes fell 14%.[55]

New Jersey Estimate

We estimate that soot pollution causes 40 to 80 infant deaths in New Jersey each year, or 5.9% to 11% of all infant deaths.

Hospitalization and Emergency Room Trips

As air pollution levels rise, children end up in the emergency room with respiratory problems at higher rates. Some of them will end up admitted to a hospital for longer-term care.

The Evidence

- Dr. Michael Friedman of the U.S. Centers for Disease Control and Prevention and his colleagues found that reduced traffic levels and higher public transit use during the 1996 Summer Olympics in Atlanta significantly reduced smog levels and also emergency room visits for childhood asthma.[56] One-hour peak ozone levels decreased by 27%, while the number of children visiting the ER for asthma fell 41.6% in a Medicaid database, 44.1% in an HMO database, and 11.1% in two major pediatric emergency departments. In other words, every 10 ppb increase in smog levels increased the relative risk of needing emergency medical attention for asthma in children by roughly 8%.

New Jersey Estimate

We estimate that air pollution causes 290 to 440 asthma hospitalizations (3.2% to 5% of total asthma hospitalizations) and at least 190 to 3,400 asthma ER visits among New Jersey children each year.

Table 11: Annual Pediatric Respiratory ER Visits and Hospitalizations Caused by Air Pollution in New Jersey

Health Effect	Number of Cases
Asthma Hospitalizations	290 to 440
Asthma ER Visits	190 to 3,400

Table 12: Annual Asthma Attacks and Acute Bronchitis in New Jersey Children Caused by Air Pollution

Health Effect	Number of Cases
Acute Bronchitis	21,000 to 77,000
Asthma Attacks	150,000 to 170,000
Missed School Days	Roughly 610,000

Asthma Attacks, Acute Bronchitis, and Missed School Days

Air pollution triggers asthma attacks and increases cases of acute bronchitis in children. Asthma is the leading chronic illness in children and the number one cause of missed school days in the United States.[59] The Centers for Disease Control estimates that asthma prevalence among persons up to 17 years old increased about 5% per year from 1980 to 1995.[60] Air pollution worsens the impact of this disease, causes other acute respiratory illnesses, and increases school absence rates.

The Evidence

- Dr. Janneane Gent at the Yale University School of Medicine and her colleagues recently published a study showing that children with asthma are vulnerable to air pollution at levels well below EPA health standards.[61] According to the study, every 50 ppb ozone increase yields a 35% increased likelihood of wheezing, and a 47% increased likelihood of chest tightness.
- Dr. Douglas Dockery at Harvard University and his colleagues showed that children living in areas with high levels of acidic particle pollution were 66% more likely to have had an episode of bronchitis in the last year than children in low pollution areas.[62]
- Researchers participating in the Southern California Children's Health Study found that increased smog pollution causes more children to stay home from school.[63] When ozone levels rose by 20 ppb, illness-related absence rates went up by 63%, and by 174% for lower respiratory illnesses with wet cough.
- Researchers in Korea found the same relationship between air pollution and school absences.[64] When air pollution levels rose, so did illness-related absences. When pollution levels fell, more children came in to school.

New Jersey Estimate

We estimate that air pollution causes 21,000 to 77,000 cases of acute bronchitis and 150,000 to 170,000 asthma attacks among New Jersey children each year. Additionally, air pollution causes in the range of 610,000 missed school days each year.

Reducing Air Pollution Protects Children's Health: The Case of the 1996 Olympics in Atlanta

The 1996 Summer Olympic Games in Atlanta offered researchers a unique opportunity to observe the connection between lowered pollution levels and improved health.[57]

Atlanta implemented a comprehensive transit plan as a part of the Olympic Games. The plan was designed to reduce congestion in the downtown area and reduce travel delays. Atlanta launched an expanded 24-hour-a-day public transportation network, added 1,000 buses for park-and-ride service, encouraged local employers to institute alternative work hours and telecommuting, and closed the downtown area to private vehicles.

The transit plan produced impressive results, despite the million or so additional visitors to the city. Weekday morning traffic trips declined by 22.7% and public transportation ridership increased by 217%.

The plan produced some unintended benefits for air quality and health that were equally impressive. The average daily maximum ozone levels decreased by 28%, from 81 ppb before and after the Olympics to 59 ppb during the Olympics. Presumably, this effect resulted from the decreased levels of traffic-related air pollution building up in the morning rush hour. Nearby cities did not experience similar reductions in ozone pollution.

At the same time, asthma-related emergency room visits for children decreased by 41.6% in a Medicaid database, 44.1% in an HMO database, and 11.1% in two major pediatric emergency departments. Additionally, hospitalizations for asthma decreased by 19.1%. Unfortunately, Atlanta discontinued the transit program at the conclusion of the Olympics, and pollution levels and emergency room visit rates returned to normal.

This study powerfully demonstrates how reducing pollution levels would benefit the health of children. It also highlights the role that motor vehicles play in creating high levels of urban pollution, and the rapidity with which pollution can be reduced from the transportation sector with better public transit.

Dr. Michael Friedman of the U.S. Centers for Disease Control, one of the authors of the study, said that the results "provide evidence that decreasing automobile use can reduce the burden of asthma in our cities and that citywide efforts to reduce rush-hour automobile traffic through the use of public transportation and altered work schedules is possible in America."[58]

Solutions to New Jersey's Air quality problems are readily available. Technologies already developed and introduced into society—from modern emission controls for cars and power plants to efficient transit systems—can cut the amounts of air pollution in New Jersey air and help people to live healthy lives.

Aggressive action will be required on both the state and federal level to reduce air pollution and reduce the costs society must bear to support the use of polluting fuels. In order to have the greatest impact, action should focus first on the largest sources of pollution.

Sources of Dirty Air

In-state, mobile sources like cars, trucks, buses, and off-road equipment are the largest source of air pollution. Additional pollutants come from industrial facilities, power plants, and chemical use. Finally, upwind sources in other states are a significant part of the overall problem.

Within the state in 1999, nearly 60% of soot emissions and almost half of smog-forming emissions came from on-road and off-road mobile sources like cars, trucks, and construction equipment (Table 13).[65] 48% of particulate emissions and 31% of smog-forming emissions came from highway vehicles.

Mobile sources have received less regulatory attention than industrial facilities and area sources of pollution. According to NJ Department of Environmental Protection emission inventories, from 1990 to 1996 mobile source emissions of oxides of nitrogen (NOx, a smog precursor) did not decline, while emissions from area and point sources were cut by half.[66] Focusing regulatory attention on mobile sources will produce the greatest air quality gains.

Policies Aimed at the Largest Pollution Sources

Although policy options available in the near future will not prevent all of the impacts identified in this report, small steps toward cleaner air will have meaningful benefits for human health. An effective suite of policies aimed at reducing air pollution in New Jersey would include the following:

State Level Actions:

- *Strengthen auto emission standards in line with New York, Massachusetts,*

Table 13. Emissions of Selected Air Pollutants in 1999 by Source[67]

	Volatile Organic Compounds (VOCs, Tons)	% of Total Emissons	Oxides of Nitrogen (NOx, Tons)	% of Total Emissons	Particulate Matter (PM10, Tons)	% of Total Emissons
Mobile Sources	154,093	38%	293,102	59%	93,238	59%
Area Sources	155,166	38%	82,662	17%	46,514	30%
Point Sources	97,880	24%	120,692	24%	17,741	11%
TOTAL	407,139		496,456		157,493	

California, and Vermont. In these states, auto makers are required to manufacture and sell vehicles that emit less pollution and incorporate advanced technologies.

- *Reduce car-dependent land use practices and sprawl.* New Jersey should ensure that future growth, development, and redevelopment focuses on creating livable, transit oriented, well centered communities to reverse the trend of yearly increases in vehicle miles traveled.
- *Increase funding for transit, rail freight, and other alternative transportation projects*. Highway construction and highway widening projects provide little long-term relief from congestion, encourage car-dependent land use patterns, and exacerbate sprawl. Increasing the proportion of funding for alternatives like transit and rail freight can help get cars and trucks off the road.
- *Require diesel engines to be retrofitted with particulate filtration systems and low-sulfur fuel*. Diesel engines are a significant source of fine particles. New federal diesel standards will go into effect in 2007, which will apply to new diesel vehicles. The state should require old diesel vehicles to upgrade their emissions control equipment as well. State-owned fleets of vehicles like school buses should be included, as well as off-road diesel vehicles like bulldozers.
- *Require diesel engines in marine vessels and trains to have selective catalytic reduction systems*. Over the past few decades, selective catalytic reduction systems have significantly reduced emissions from power plant smokestacks in New Jersey. The same technology can be applied to diesel engines on railroads and in marine vessels.

Federal and Regional Level Actions:

- *Advocate adoption of these state policies among neighboring and upwind states*. Reducing air pollution emissions in New Jersey will have benefits for New York, Philadelphia, and other upwind areas as well. These actions can serve as an incentive for other states to take similar action against air pollution. Ultimately, regional cooperation will be required to reduce overall air pollution levels.
- *Restore the New Source Review provision of the Clean Air Act and require the oldest coal-fired power plants and other industrial facilities in the country to install modern emissions control technology.* The EPA recently enacted regulations relieving power plants and industrial facilities grandfathered under the original Clean Air Act of responsibility to upgrade their emissions controls when upgrading their facilities. This change limits the effectiveness of the Clean Air Act and effectively subsidizes a few industries at the expense of public health. It should be undone as soon as possible.
- *Limit nationwide industrial emissions of sulfur dioxide, nitrogen oxides, and mercury to between 10% and 30% of 2000 levels*. Placing a national cap on point-source emissions of air pollutants could dramatically reduce the levels of pollution plaguing the eastern seaboard of the U.S., and could contribute to a regional solution to the air pollution problem.
- *Strengthen national emission standards for cars, trucks, and off-road vehicles*. The EPA sets national emission standards for cars, trucks, and off-road vehicles. However, California

has designed a more effective and ambitious mobile-source emissions control program that includes a requirement for manufacturers to produce cleaner vehicles with modern technologies. The EPA should update its standards to match the California program.

Methodology

To quantify the health impacts of air pollution, we acquired three basic pieces of information:

- The exposure of people to air pollutants,
- How the frequency and risk of a given health impact changes with increasing or decreasing air pollution levels, and
- The baseline frequency of a given health problem in society.

Air pollution monitors placed throughout the state by the New Jersey Department of Environmental Protection help provide the first piece of information. A vast body of scientific literature in which researchers tracked pollution and health effects provides the second piece of information. And the third comes from health statistics maintained by the state Department of Health and Senior Services, plus additional information from surveys and experiments in the scientific literature.

We compiled this information to estimate the health impacts of pollution in New Jersey, adapting methodology used by the U.S. EPA in a study on the benefits and costs of the Clean Air Act and by the World Health Organization in a study on the health impact of vehicle pollution in Europe.[68] The sections below outline the sources of this information and how we used it to derive our results.

Air Pollution Exposure

We obtained annual mean levels of particulate pollution less than 10 micrometers in diameter (PM10 or fine soot) from the U.S. EPA AIR*Data* online database of air pollution monitoring data, using the years 1997 to 2001.[69] Additionally, we obtained the average daily one-hour peak ozone levels reported during the summer smog season from April through October from the same source.

Several assumptions and generalizations were made to calculate exposure levels for the New Jersey population. The purpose of these assumptions was to obtain a reasonable estimate of individual exposure in the absence of detailed data for every part of the state. First, we assumed that mean pollution levels for each county approximated exposure for the average resident of that county. Second, for counties without active PM10 monitors but with active PM2.5 monitors, we adjusted the PM2.5 readings to estimate PM10 levels. According to instances in which each pollutant was monitored in the same place at the same time, PM2.5 levels are typically 55% of PM10 levels. Third, for counties without active pollution monitors, we conservatively used background measurements from monitors in rural Passaic county with the lowest statewide readings of all active monitors during this period. For particulate matter, these counties included: Burlington, Cape May, Hunterdon, Monmouth, Salem, Somerset, and Sussex. For ozone, these counties included Burlington, Cape May, Salem, Somerset, Sussex, and Warren.

Table 14 presents the results of compiling air pollution data from 1997 to 2001.

We define the impact of air pollution as the change in the number of various health outcomes if air pollution exposure was reduced to natural background levels in the absence of anthropogenic emissions from North America, but with continuing emissions from the rest of the world. For ozone, this background level in the Northeast is 20 ppb.[70] For particulate matter, this background is 5 micrograms per cubic meter.[71]

Table 14: Average Annual and Smog Season Pollution Levels in New Jersey

County	Annual Average PM10 levels (micrograms per cubic meter)	Monitor in County?	April - October Average Daily One Hour Peak Ozone Levels (ppb)	Monitor in County?
Atlantic	25	Yes	59	Yes
Bergen	39	Yes	49	Yes
Burlington	16	No	56	No
Camden	27	Yes	64	Yes
Cape May	16	No	56	No
Cumberland	18	Yes	59	Yes
Essex	34	Yes	47	Yes
Gloucester	18	Yes	61	Yes
Hudson	37	Yes	53	Yes
Hunterdon	16	No	59	Yes
Mercer	24	Yes	60	Yes
Middlesex	23	Yes	59	Yes
Monmouth	16	No	56	Yes
Morris	22	Yes	58	Yes
Ocean	20	Yes	62	Yes
Passaic	25	Yes	56	Yes
Salem	16	No	56	No
Somerset	16	No	56	No
Sussex	16	No	56	No
Union	33	Yes	50	Yes
Warren	25	Yes	56	No

Baseline Frequency of Health Problems in New Jersey

We obtained the baseline frequency of health outcomes in New Jersey from statistics maintained by the New Jersey Department of Health and Senior Services Health Statistics Division or, when more specific information was unavailable, published estimates for the American population as a whole from the U.S. EPA.

We obtained New Jersey county population figures by age group from the U.S. Bureau of the Census for 2000 to translate the relevant rates in Table 15 to baseline population frequencies for the state.[87] Additionally, we assumed that one third of all health effects that could be affected by ground-level ozone happened during the April through October ozone monitoring season, and only considered the effects of ozone on that period of time. This assumption is supported by hospital admissions data cited in Table 15 – in 2002, 118,435 New Jersey residents were hospitalized for respiratory causes, and 40,005 hospitalizations, or 33.78%, happened in the months of May through September. [88]

Table 15: Baseline Frequencies of Health Problems in New Jersey

Health Outcome	Baseline Frequency in New Jersey
Mortality (Deaths per person per year), excluding violence or accidental deaths.[72]	0.0081 to 0.0085
Infant mortality (all causes).[73]	Data obtained by county of residence for 1997-2000 from the NJ Center for Health Statistics.
Respiratory hospital admissions (ICD 390-459).[74]	Data obtained by county of residence for 1997-2001 from the NJ Center for Health Statistics.
Cardiovascular hospital admissions (ICD 460-519).[75]	Data obtained by county of residence for 1997-2001 from the NJ Center for Health Statistics.
Asthma hospital admissions for children 0-15 years of age.[76]	Data obtained by county of residence for 1997-2001 from the NJ Center for Health Statistics.
Annual chronic bronchitis incidence per person.[77]	0.0038
Annual chronic asthma incidence among adults 27 years of age and older in ozone season.[78]	0.0011
Asthma prevalence among adults in NJ.[79]	11.8%
Asthma attacks per asthmatic per year.[80]	9.86
Asthma ER visits per year among all children 0-15 years of age.[81]	0.01
Asthma ER visits per year among adults.[82]	0.0071
Number of children per year who get acute bronchitis.[83]	4.4%
Yearly missed work days per worker due to illness (adults between the ages of 18 and 65).[84]	1.6
School absences per student per year due to illness.[85]	6
Restricted activity days per person per year.[86]	6.46

General Equation: Air Pollution Attributable Portion of Health Effects =

$$\frac{(RR - 1) \times (\Delta Pollution)}{(RR)} \times (\text{Baseline Frequency of Outcome in Vulnerable Population})$$

The Relationship Between Exposure and Frequency of Health Effects

A vast body of scientific literature in which researchers tracked pollution and health effects provides information about how the frequency of health effects changes with changing exposure to air pollution. These studies are known as epidemiological studies. Most epidemiological studies report the exposure-response relationship for air pollution exposure as a relative risk (RR). If the relative risk equals 1, then the pollutant in question does not influence the health outcome. If the relative risk exceeds one, then the pollutant and the health outcome are linked. Most studies report a considerable range in which the relative risk actually lies. This is called the confidence interval. We use the upper and lower bounds of these intervals to derive the ranges for each health effect we report.

Calculating the impact of air pollution on a given health outcome follows the general equation shown above.[89]

We obtained exposure-response functions from epidemiological research published in the scientific literature as compiled in:

1) The U.S. EPA's report to Congress on the benefits and costs of the Clean Air Act[90] and

2) A project describing the health impacts of vehicular air pollution in Switzerland, Austria, and France carried out by European scientists and the World Health Organization.[91]

Particulates (PM10)

Table 16 lists the relative risk numbers for an increase in particulate matter pollution of one microgram per cubic meter derived from epidemiology studies, the confidence limits, and the citation for the original study.

Ozone

Table 17 lists the relative risk numbers for an increase in ground-level ozone pollution of one part per billion derived from epidemiology studies, the confidence limits, and the citation for the original study.

For studies which used ozone measurements other than the daily one hour peak concentration, we used the following estimated conversion factors: 12 hour ozone levels are 50% of the daily one hour maximum, 8 hour ozone levels are 70% of the daily one hour maximum, and 5 hour ozone levels are 85% of the daily one hour maximum. We estimate these conversion factors based ozone monitoring data for New Jersey.[113]

Children, PM10

Table 18 lists the relative risk numbers for children for an increase in particulate matter pollution of one microgram per cubic meter derived from epidemiology studies, the confidence limits, and the citation for the original study.

Table 16: Relative Risk Figures Derived from the Scientific Literature, Particulate Matter

Health Effect	Relative Risk of Effect	95% Confidence Limit	5% Confidence Limit	Reference
Premature Death	1.0043	1.0026	1.0061	92
Respiratory Hospital Admissions	1.0017	1.0013	1.002	93
Cardiovascular Hospital Admissions	1.0008	1.0004	1.0011	94
Asthma Attacks	1.0039	1.0019	1.0059	95
Chronic Bronchitis	1.0098	1.0009	1.0194	96
Work Loss Days	1.0046	1.00424	1.00496	97
Restricted Activity Days	1.0094	1.0079	1.0109	98
Increased Symptom Days	1.168	1.081	1.256	99

Table 17: Relative Risk Figures Derived from the Scientific Literature, Ozone

Health Effect	Relative Risk of Effect	95% Confidence Limit	5% Confidence Limit	Reference
Long-Term Mortality	1.000634	1.000383	1.000885	100
Adult Onset Asthma	1.0277	1.0142	1.0412	101
Respiratory Hospital Admissions	1.0025	1.001782	1.003218	102
Asthma ER Visits	1.0035	1.0017	1.0053	103
Asthma Attacks	1.00184	1.001126	1.002554	104
Restricted Activity Days	1.0022	1.001542	1.002858	105
Increased Symptom Days	1.000137	1.0000673	1.0002067	106
Asthma ER Visit, Children 0-15 years of age	1.008	1.001	1.0186	107

Table 18: Relative Risk Figures Derived from the Scientific Literature, Particulate Matter, Children

Health Effect	Relative Risk of Effect	95% Confidence Limit	5% Confidence Limit	Reference
Neonatal Mortality	1.00392	1.0027	1.00514	108
Asthma Hospitalizations	1.0025	1.001782	1.003218	109
Acute Bronchitis	1.0306	1.0135	1.0502	110
Asthma Attacks	1.0051	1.0047	1.0056	111
Missed School Days	1.004	NA	NA	112

NOTES

1. The air pollution data here represents the 1997-2001 annual average for particulates and the 1997-2001 April – October average one hour daily peak for ozone: U.S. EPA, *AirData: Access to Air Pollution Data*, downloaded from www.epa.gov/air/data/, on 3 November 2003.

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