Air Pollution and Health

Background and Summary on Air Quality and Health Issues

Population Health, Community Service, and Critical Thinking Unit (PHCSCT)
Placement: Clean Nova Scotia
Kimberley Creaser, Class 2005
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Table of Contents

Table of Contents
Objectives Provided By Clean Nova Scotia
Population Health Project Evaluation Guide
Search Strategy and results of Literature Search
Web Site Reference List
Useful & Interesting Scientific Reviews Studies
Introduction
Air Pollution
Table 1: Common Sources of Emissions
Issues in Nova Scotia
Health Effects
Table 3: Summary of Air Pollutants and know health effects
Ozone and Smog
Particulate Matter
Mercury
Populations at Risk
Asthma
Conclusions
Solutions
Summary
Appendix A – Additional Website Resources
Appendix b – Pub Med Search
Web Site Reference List

Air Pollution & Health Slide Show

Environment Canada – Atlantic Region – Air Pollution Topics & Resources
http://www.ns.ec.gc.ca/pollution/air.html

http://www.epa.gov/oar/oagps/air_risc/3_90_023.html

EPA Publication – Air Pollution and Health Risk
http://www.epa.gov/oar/oagps/air_risc/3_90_022.html

UK Dept. of Health – Health Effects of Climate Change
http://www.doh.gov.uk/airpollution/climatechange02/index.htm

UK Dept of Health - THE HEALTH EFFECTS OF AIR POLLUTANTS: ADVICE FROM THE COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS
http://www.doh.gov.uk/comeap/statementsreports/healtheffects.htm

UK Dept of Health – Asthma and Outdoor Air Pollution
http://www.doh.gov.uk/comeap/statementsreports/airpol2.htm

UK Dept of Health – Air Pollution Statements & Reports
http://www.doh.gov.uk/comeap/state.htm

World Resources Institute – Health & Environment – The Health Effects of Air Pollution

Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999
http://www.ewjm.com/cgi/content/full/176/3/157

CBC News - Air pollution a significant health risk for Canadians
http://www.cbc.ca/stories/2002/06/07/Consumers/smog_020607

Canadian Public Health Association - Resource Development to Raise Public Awareness About the Health Effects of Air Pollution and Actions to Improve Current Conditions
http://www.cpha.ca/english/natprog/airpollu/airpol_e.htm

Canadian Public Health Association – Climate Change and your child's health
http://www.cich.ca/Climate_Change/English/AirPollution.htm#_Air_Pollution_1

Canadian Public Health Association - Air Pollution and Senior’s Health

Canadian Health Network – How Does Air Pollution Affect Our Health?
http://www.canadian-health-network.ca/faq-faq/environmental_health-sante_de_l'environnement/7e.html

Environment Canada - Air Care: A parent’s guide to air quality and health
http://www.ns.ec.gc.ca/udo/air.html

BEWARE THE AIR YOU BREATHE: ONTARIO’S DOCTORS CALL FOR CLEANER AIR
OMA Ground Level Ozone Position Paper
http://www.oma.org/phealth/ground.htm

Pollution Probe – Air Quality Publications
http://www.pollutionprobe.org/Publications/Air.htm

Environment Canada – Clean Air
http://www.ec.gc.ca/air/health_e.shtml

Environment Canada – Clean Air – Atlantic Canada and Clean Air
http://www.ec.gc.ca/air/fact_atlantic_e.html

Environment Canada – Mercury in Atlantic Canada: A Progress Report

AIR POLLUTION AND ACTIVE TRANSPORTATION

AIR POLLUTION, CLIMATE CHANGE AND YOUR HEALTH
http://www.hc-sc.gc.ca/hecs-sesc/air_quality/factsheet/climate.htm

HEALTH EFFECTS OF AIR POLLUTION
http://www.hc-sc.gc.ca/hecs-sesc/air_quality/health_effects.htm

SMOG AND YOUR HEALTH
http://www.hc-sc.gc.ca/english/iyh/environment/smoq.htm

Air Pollution and Asthma
http://www.asthma.ca/adults/lifestyle/outdoor.php

NB Lung Association - The Healthy Wood Stove
http://www.elements.nb.ca/theme/winter/woodstov/woodstov.htm

Canadian Lung Association – Outdoor Air Pollution
http://www.bc.lung.ca/airqualityfactsheets/outdoor_air_quality_factsheet.htm

Lung and Asthma Information Agency
http://www.sghms.ac.uk/depts/iaia/iaia.htm

Health and Clean Air Newsletter
http://healthandcleanair.org/newsletters/

Environment Canada - Major Pollutants
http://www.atl.ec.gc.ca/airquality/pollutants_e.html

Climate Change in Nova Scotia

Useful & Interesting Scientific Reviews Studies

For a detailed list of reviews please refer to the references.


Helen Suh, Tina Bahadori, Jose Vallarino, and John Spengler. Criteria Air Pollutants and Toxic Air Pollutants. Environ
Introduction

In April 2002 the Canadian Medical Association Journal published a paper on Outdoor air pollution as part of a series addressing environmental health effects.\(^1\) There is a growing body of knowledge that has demonstrated that there are health effects directly related to air pollution. As physicians we are in a position to educate patients about these effects and recognize who is at higher risk for developing serious health illness due to air pollution. The goals of this paper are to provide background information to physicians about air pollution and attempt to provide a review of some of the current literature and encourage physicians to adopt strategies to reduce air pollution in response to a growing public health issue.

Since the seventies researchers have begun to link serious health effects to air pollution and during the nineties research papers correlating health effects with levels of air pollution entered the primary literatures.\(^2\) We are now in a position where we can say that air pollution does adversely affect health and it is a problem in Canada. The Canadian government has estimated that air pollution is responsible for 5,000 premature deaths annually; this translates into 8% of all accidental deaths being a direct consequence of air pollution from the combustion of fossil fuels. In Ontario 9,800 people are admitted to hospitals and 13,000 visit emergency departments as a result of exposure to smog.\(^3\) Known adverse health effects of air pollution include respiratory symptoms stemming from airway hyper-reactivity, lung inflammation, decreased lung function, reduced exercise capacity, possible increased use of medications and increased visits to emergency departments and physician offices, and possible increased mortality.

In order to educate our patients and act as advocates it is important for physicians to have an understanding of the issues relevant to air pollution. Three conditions have been described as empowering people to make decisions with regard to personal action; an understanding that there is a problem, an understanding that we are contributing to the problem, and knowledge of solutions. The importance of these conditions holds true for the general population. The following article highlights some of the reasons why physicians should care about climate change and specifically issues of air quality. This background paper intends to provide some information for medical practitioners with some knowledge of air pollution issues and health effects. The value of this information is not limited to the medical profession and can be used for educating any member of the public about the health effects of air pollution. There are many reviews addressing the issue of health effects of air pollution this paper will not repeat all information presented in the available reviews but will attempt to address some the key issues.
While politicians dilly-dally about whether to make a concrete commitment to the Kyoto Protocol, agonizing over possible negative effects on the economy, the Canadian Medical Association (CMA), official voice of Canadian physicians, has no such hesitations. "For our members, more than 53,000 physicians across Canada, this international accord is a commitment to improve health status of our citizens and people around the world. ... CMA urge[s] the federal government to ratify the Kyoto Protocol and adopt a strategy that will reduce Canada's greenhouse gas emissions by at least 6% below 1990 levels by 2012."

Why doctors care about climate change?

Consider these facts:

- close to 8% of all non-accidental deaths in Canada are caused by air pollution resulting from by-products from burning fossil fuels
- following smog days, hospital admissions for respiratory problems increase by 6%, admissions of infants with respiratory problems increase by 15%
- forecasts show that without reductions in fossil fuel consumption, in 20 years there will be a 60% increase in particulate emissions with a corresponding increase in respiratory illnesses, hospitalization and health care costs.

Air pollution is caused by the by-products of fossil fuel consumption, the same products which cause climate change. So cutting back on the contributors to air pollution is also a step towards decreasing greenhouse gases and global warming.

Not cutting back means an increase in greenhouse gasses, which means an increase in hot, smoggy days. Increased heat and humidity lead to more heat related deaths, as well as increases in smog and air pollution advisories and increases in pollens and mold spores in the air. People with heart problems, respiratory diseases and allergies are all affected.

"Ralph Klein says the issue is greenhouse gasses, not air pollution, but you can't talk about one without talking about the other," says Ken Maybee, President of the NB Lung Association. Maybee underlines the correlation between the use of fossil fuels, increasing greenhouse gasses and increasing air pollution, which exacerbate health problems for those suffering from respiratory diseases including asthma, emphysema, and chronic obstructive pulmonary disease. "It's essential that the general public understand that as greenhouse gases increase, so will the effects of air pollution, low level ozone (smog) and particulate matter in the air,” says Maybee.

Smog is not a problem restricted to major urban areas. Nova Scotia's agricultural Annapolis Valley is the site of the highest smog levels in Nova Scotia, and smog advisories in the area were numerous this past summer.

Fifty health organizations and more than two thousand individual physicians and health scientists have signed the David Suzuki Foundation's Physician's Statement on Climate Change, which calls for immediate and decisive action on Kyoto. They note that "reducing fossil fuel use will improve air quality and protect the climate, both of which are key factors in public health."

A March 2002 report from the US National Academies' National Research Council, Abrupt Climate Change:Inevitable Surprises, warns that people can expect "climate surprises" in the form of "large, abrupt and unwelcome regional or global climatic events," including drought, floods, extreme heat, hurricanes and rising sea levels.

Dr. Paul Epstein, associate director of the Center for Health and the Global Environment at Harvard Medical School, says the report indicates that "we've underestimated the rate of this change, we've underestimated the sensitivity of biological systems, we've underestimated the cost of global warming."

In a paper printed in the Canadian Medical Association Journal in September 2000, Epstein and co-authors Andrew Haines and Anthony J. McMichael detail the widespread potential health impacts from climate change. Direct effects include illness and deaths from heat waves, drought, floods, storms and the breakdown of systems in the aftermath of weather disasters. Indirect effects include decreased crop productivity owing to pests and climate change, changing water availability, lower air quality, rising sea levels and animal-based diseases appearing in regions in which they had previously been unheard of.

Global warming is already resulting in the spread of infectious diseases, as tropical insects which carry these diseases move north and south of their traditional territory. Insect populations increase with warmer winters and better breeding conditions in summer. Projections show that malaria, dengue fever and yellow fever could appear in Canada as insects carrying them migrate north. Epstein links drought intensified by climate change to the spread of the West Nile virus.

Climate change can also threaten the quantity and quality of drinking water. Water sources may be threatened by drought, as well as by increased contamination from bacteria, viruses, protozoa and parasites.
Inaction on global warming is costly. Economists estimate that health benefits from improving ambient air quality in Canada would amount to $8 billion over 20 years. The CMA states, “While opponents are eager to argue that signing on will have a negative impact on Canadian industries, they conveniently ignore the impact inaction will have on the health and well being of Canadians and others around the world. ... Reducing ... emissions would provide significant health benefits, not only in terms of the number of adverse health effects that can be avoided but also the economic cost of illnesses due to these health effects - an unhealthy workforce does not lead to a strong economy.”

The bottom line is, there are many ways to run an economy, but there is no substitute for clean air, clean water and good health.

What you can do... While policy changes by government are important, individual action also helps cut greenhouse gasses. Driving less, and driving fuel efficient vehicles, making your home more energy efficient, and only heating when you need to, and letting politicians know you support Kyoto are valuable ways individuals can help. For more information on climate change and what you can do, check out www.davidsuzuki.org.

© http://www.environmentalhealth.ca/fall02doctors.html

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**Air Pollution**

Air pollution is an umbrella term used to define air contamination with both primary and secondary pollutants. Primary pollutants are those substances that directly affect the respiratory system such as carbon dioxide, carbon monoxide, nitrogen dioxide, sulfur dioxide, and fine particles (dust, tobacco, sulfur containing fuels, pollen, bacteria, acidic aerosols). Secondary pollutants are those substances that affect the respiratory system through interaction with primary pollutants such as aerosols (smoke, fog, mist), ozone, and peroxyacetyl nitrate (an active component in smog). The Environmental Protection Agency has identified six criteria air pollutants. These criteria include: Particulate Matter 10 μm (or PM10), PM2.5, ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead. In addition to the six criteria air pollutants there are an identified one hundred eighty-nine potentially harmful air pollutants (or HAPs). The HAPs include metals, gases, other particles and vapours. Most pollutants are created as a result of human activity; Table 1 illustrates the common sources of air pollutants. Further discussion of some specific pollutants will occur later in this paper.

<table>
<thead>
<tr>
<th>Sources of Green House Gas Emissions</th>
<th>81%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Industry</td>
<td>36%</td>
</tr>
<tr>
<td>Transportation</td>
<td>26%</td>
</tr>
<tr>
<td>Residential, Commercial, Institutional</td>
<td>11%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>8%</td>
</tr>
<tr>
<td>Industrial</td>
<td>7%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>8%</td>
</tr>
<tr>
<td>Waste, Deforestation and Other</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 1: Common Sources of Emissions
Smog warning issued for Nova Scotians

HALIFAX (CP) -- Nova Scotians with lung problems should stay inside until pollution levels drop, Environment Canada warned Monday. The federal department issued a smog advisory for most of Nova Scotia, saying the air quality forecast for Tuesday is even worse. "The advisory has been issued for all of the province, except the Eastern Shore and Cape Breton," said Ted McIldoon, a forecaster with Environment Canada. Health Department spokesman Morris Green said people with respiratory conditions -- especially the young and seniors -- should stay indoors and avoid strenuous activity while the smog alert is in effect. Bill VanGorder, president of the Nova Scotia Lung Association, said people with lung disease need to be concerned about the warning. "Smog irritates the airways," he said. "When they become irritated they tighten, just like when you get something in your eye and your eye closes. "When airways tighten, breathing becomes more difficult." One in four Nova Scotians has some form of lung disease. McIldoon said even people without lung problems could be affected by the polluted air. "People without medical conditions can experience eye irritation and shortness of breath," he said. Serge Desormeaux, meteorologist with the New Brunswick Weather Centre in Fredericton, said the smog levels Monday were just above the advisory index. "It's just a borderline warning," he said. "But we are confident some parts of Nova Scotia will experience high values." He said the smog, created by car exhaust fumes and industrial smoke, originally drifted in from the Great Lakes region, but a shift in wind patterns is causing New England pollutants to gather here.

Issues in Nova Scotia

Reports like the one above have become more common over the past few years. Air Quality has become and issue in Nova Scotia, and Nova Scotia has had air quality events with levels of ozone (smog) and PM2.5 exceeding the national standards. One of the objectives of this paper is to provide information that is relevant to Nova Scotia, this section will highlight some of the issues specific to Nova Scotia. Environment Canada has identified smog, acid rain, mercury, and pesticides to be specific air quality issues in Atlantic Canada. The levels of these pollutants are higher than the national standard. The contributors to the high levels of these substances are both long-range transport from central Canada and the eastern United States and human activity within our region. It is important to recognize the contribution of human activity in Nova Scotia, as this is the area where individuals can implement change. According to a 1995 emissions study Nova Scotia is the third highest producer of particulate matter due to wood burning in Canada. Also, Nova Scotia was the highest producer of sulfur oxides due to non-industrial fuel combustion. Wood is very common in Nova Scotia as a method of heating homes. The burning of wood produces particulate matter such as soot and ash, carbon monoxide, nitrogen oxides, and hydrocarbons. The amount of these substances produced depends on the amount of burning and the efficiency of the stove. An older uncertified wood stove can produce as much as 80 grams of smoke per hour, where as the new EPA certified stoves produce less than 5 grams of smoke per hour. Automobile emissions are also a significant source of pollution in Nova Scotia. Table 2 provides a brief summary of the Air Quality Forecast in Nova Scotia from the 2002 summer. There were 4 days in Nova Scotia from July - September with a poor air quality forecast. Southwestern Nova Scotia, represented in part by the Alyesford Mountain monitoring station had the most fair poor air quality forecasts in the summer of 2002. Southwestern Nova Scotia, is upwind of major provincial emission sources thought to be the major source of the poor air quality. Southwestern Nova Scotia routinely has the highest ozone levels in the province, which includes elevations in particulate matter as well. Ironically the region with the poorest air quality is also the region home to Kejimkujik National Park. In Halifax, the major pollutant tends to be particulate matter. In a 2001 report it was estimated that the levels of PM2.5 needed to be decreased by 10% to reach the national standards. The major source of particulate matter in the Halifax area is from the burning of oil for power generation, the refinery and institutions. Particulate and ozone levels in industrial Cape Breton rarely exceed the national standards. It is important to note from this sample of data that air quality is a growing issue in Nova Scotia. Little data is published on the effects of air pollution in Nova Scotia, however recognizing that the same constituents of pollution are present in Nova Scotia as are in other areas of Canada and the US one can draw conclusions from studies in other geographic areas to understand the health effects associated with pollution.
Table 2: Summary of Air Quality Forecast during July – September 2002 at Nova Scotia Air Monitoring Stations. Categories of predicted levels of ground-level ozone (smog); good (0-25), fair (26-50), poor (51-100), very poor (>100). The recommended standard for ozone in Canada is 65ppb. Only forecasts predicting air quality lower than good are shown.

<table>
<thead>
<tr>
<th>Location</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halifax</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Aylesford</td>
<td>0</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Pictou</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Dayton</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Sydney</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>0</td>
<td>4</td>
<td>70</td>
</tr>
</tbody>
</table>

Health Effects

It is important to understand what the definition of an adverse health effect is. The American Thoracic society has discussed what defines an adverse health effect: “Where one draws the line to categorize it as an adverse health effect or an action level between pathophysiologic or physiologic change is probably best left to the individual or the community.” Figure 1 illustrates the varying severity of adverse health effects and the various end points that we can measure. It is important to note and understand that severe adverse health effects such as mortality and hospital admissions are the tip of the iceberg and air pollution can cause many health effects that are subtle enough to not warrant seeking medical attention. The ATS has further described a more scientific definition for adverse health effects as a medically significant physiologic or pathologic activity as interfering with the normal activity of a person, and episodic respiratory illness, incapacitating illness, permanent respiratory injury or progressive respiratory dysfunction.

Figure 1: Pyramid of Health Effects of Air Pollution

When discussing the adverse health effects of substances it is important to note both those effects that present acutely and those that are associated with chronic exposure. Often it is difficult to accurately assess the effect of chronic or long-term exposure on the health of individuals, despite the fact that the data may not always be available, one must remember that chronic exposure to low level concentrations of potentially damaging and toxic substances can be significant. The degree of health effect will depend on the duration of exposure and the concentration of the pollution. The type of long term health effect will depend on what the exposure to pollution is and the quantity of exposure. There is a wide range of health effects. Acute effects include symptoms resulting from irritation of the mucous membranes in the eyes, nose and throat; cough, wheezing and chest tightness; airway hyper-responsiveness; tracheobronchitis; exacerbations of asthma; death in those with significant cardiopulmonary disease. Chronic effects include long term decreases in lung function, chronic tracheobronchitis, airway remodeling, and increased susceptibility to chronic lung diseases. The common effect of air pollution is on the respiratory system, and each pollutant carries of risk of adverse health effects due to exposure. In general air pollution at high levels has been shown to increase the risk of premature death, the results are summarized in Table 3.

Table 3: Summary of Air Pollutants and know health effects

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Source</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter</td>
<td>Primary Particulate Matter: Natural sources – fog, dust, smoke</td>
<td>Inspirable particulate matter &lt; 10 microns, remains in air for minutes to hours, and can travel a few hundred meters to as much as 50km</td>
</tr>
<tr>
<td></td>
<td>Human activities – Combustion of fossil fuels, mining &amp; milling, road dust, gaseous emissions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary Particulate Matter: Results from chemical reactions in the air with gases and volatile heavy metals</td>
<td></td>
</tr>
<tr>
<td>Ground level ozone (O3)</td>
<td>Interaction of nitrogen dioxides and volatile organic compounds in the presence of light. Formed by the combination of 3 oxygen molecules</td>
<td>Symptoms of chest tightness, shortness of breath, cough, wheeze, pulmonary inflammation, declines in lung function, increases in bronchial hyper reactivity, exacerbations of allergen induced asthma. Development of asthma, increased emergency room visits, increased hospitalizations, and increased mortality rates. Effects of ozone exposure last up to 18hrs following exposure. 1.4% increase in premature death</td>
</tr>
<tr>
<td>SMOG</td>
<td>fumes from cars, trucks, lawnmowers, boat engines, ATVs and other fuel powered engines, as well as, the emissions from manufacturing plants, dry cleaners and coal or gas-fired power plants.</td>
<td>Chest tightness, difficulty breathing, exacerbations of asthma (see ground level ozone)</td>
</tr>
<tr>
<td>Nitrogen oxides (eg. NO2)</td>
<td>Combustion of fossil fuel, vehicle emissions, power generation, oil refineries, wood burning NO2 can combine with water for form nitric acid which contributes to acid rain</td>
<td>Causes irritation to the respiratory system results in coughing, wheezing and shortness of breath. 5.35% increase in premature death</td>
</tr>
<tr>
<td>Volatile Organic Compounds</td>
<td>Natural vegetation (main source) – plants and trees Human activities: combustion of gasoline, diesel and fossil fuels; solvents and dry cleaning chemicals</td>
<td>Contribute to the formation of smog and secondary particulate matter</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>Energy generation, combustion of hydrocarbons (gasoline)</td>
<td>2.5% increase in premature death</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>Combustion of fossil fuels</td>
<td>Eye irritation, shortness of breath, decreased lung function, inflammatory changes precipitating asthma 1.8% increase in premature death</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Natural Sources and Human activity</td>
<td>Headache, drowsiness, arrhythmias, coma, death</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>Combustion and burning of fossil fuels</td>
<td>Drowsiness, coma, death</td>
</tr>
</tbody>
</table>

*Increases in premature death from
Ozone and Smog

Smog is a composition of pollutants and particulate matter; the term historically was used to describe a mixture of smoke and fog. What smog now refers to is a combination of toxic vapors, gases and particles. Ground level ozone is the primary component of Smog. Ground level ozone is what is measured to provide air quality forecasts. Smog is formed through a reaction involving nitrogen dioxides and volatile organic acids in the present of heat and sun. Volatile organic acids are gases and vapours that evaporate easily and quickly. Sulfur dioxide is one of the smog pollutants and is important because it can persist in the environment when it combines with water to form sulfuric acid, a major constituent of acid rain. The reaction producing smog depends on weather, time of year, topography, wind speed and direction to urban and industrial centers. Air quality indexes measure both the levels of ground level ozone and smog and then report days of high risk of health effects.

Ozone is an unstable gas that can act as an oxidant and causes irritation of mucous membranes and lung tissues. Acutely, ozone causes decreased respiratory function, cough and chest tightness. It is not surprising that most effects can be noted in individuals who are more physically active outdoors, thus having increased exposure time. It has been suggested that decreased inspiratory capacity in relation to ozone exposure could be a protective effect and not an adverse health effect at all, however we know that there is significant inflammation in response to increased ozone levels. Ozone is the only pollutant that was found to have a significant effect on lung growth measured by changes in FEV1 in a 3 year cohort study of children. Studies have indicated that there is a dose dependent effect of ozone on acute events in children requiring medical attention. In one study in Atlanta during the Olympics a 42% decrease in asthma acute events in children was associated with a 28% reduction in ground level ozone attributed to increased public transportation. Airway inflammation is a known result of ozone exposure. At the molecular level it appears that neutrophilic infiltration is the main cause of the inflammation. A consequence of the airway inflammation is airway remodeling, which can result in the ultimate effect of decreased in lung growth. Despite this knowledge there doesn’t seem to be a consensus among researchers about the overall effect of ozone on lung function and health. One of the reasons for this uncertainty is the variable effects that can result from equal ozone exposure to different groups of individuals, this variation is thought to be due to the differing sensitivity of individuals to ozone. More information is needed to determine the pathophysiology of lung damage due to ozone exposure. What we do know is that the ground level ozone present in smog is associated with adverse health effects.

Particulate Matter

Particulate matter originates from various sources depending on whether it is fine or coarse. Fine particulate matter refers to particles that are less than 2.5 \( \mu \text{m} \) designated PM2.5 and can be composed of carbon material, nitrates or sulfates, other compounds or water. Coarse particulate matter refers to particles that are 10\( \mu \text{m} \) in size designated PM10 and often arises from mechanical manipulation of hard surfaces and substances. The effect of particles on the respiratory system depends
on the size of the particulate matter. Inspired particulate matter < 10 microns, remains in air for minutes to hours, and can travel a few hundred meters to as much as 50km. Respirable Particulate matter < 2.5 microns, remains in the air for days to weeks and can travel as far as 800km. PM2.5 are labeled respirable particles and can penetrate deep in the respiratory system reaching the alveoli. PM10 are labeled inhalable are taken into the respiratory system but don’t penetrate deep within the lungs. Particles from a direct source are referred to as primary particles, where as those that form from chemical reactions with gases is referred to as secondary particulate matter. Particulate Matter has been associated with increased mortality and morbidity in a variety of studies. A relative risk of 1.015 – 1.085 for mortality has been found in studies where particulate concentrations are 50 μg/m3.11 The interpretation of the health effects associated with particulate matter has been somewhat controversial due to the fact that particulate matter is composed of a number of pollutants and has a variable composition in different geographic settings and at different times. However, exposure to some specific substances can cause significant effects, an example is diesel exhaust, which is known to cause airway leukocyte inflammation and can precipitate asthma. Increased particulate matter has been associated with respiratory irritation, acute asthma events, asthma like symptoms and cardiovascular disease. From an analysis of reviews in the literature there does not seem to be a threshold for PM10 exposure below which there are no adverse effects.13 Adverse outcome associated with PM10 tend to be more severe in individuals who have pre-existing cardiac or respiratory pathology.15 Additional studies have shown direct effects of particulate matter PM10 cause a reduction in peak expiratory flow rates in children.16 All cause daily mortality (the total number of deaths per day) increased by 0.6% (95% CI 0.4–0.8) for each 10 μg/m3 increase in PM10. In some experiments using concentrated airborne particles no changes in lung function have been associated with exposure.17 Exposure to the PM2.5 is known to bronchospasm, congestions and bronchitis. It has been difficult for studies to identify the effects of particulate matter on lung function and the health of individuals due to the heterogeneity of particulate matter in the air and the tendency for smog (and ambient air) to contain a number of different particles at any given time. However, the literature does show that increases in particulate matter are associated with mortality, exacerbations of asthma and COPD and admissions of cardiovascular disease.18

Mercury

While the intent of this paper is not to review the literature regarding health effects of mercury a summary of information will be provided because of its recognized contribution as an air pollutant in Atlantic Canada. Mercury is predominately emitted into the air from coal-fired power plants. Mercury is an important pollutant, as it can remain suspended in the environment for more than 30 days. Mercury can be transformed into methylmercury in acidified lakes and during times of elevated ozone generally in the summer. One particular danger with mercury is that it can bioaccumulate, which is a concern with populations who are reliant on fish consumption in high mercury level areas. Although mercury is transported through the air most mercury exposure occurs via absorption from foods. Inhalation of mercury can occur in cases of spills. Mercury is neurotoxin and can produce central nervous system lesions that can result in paresthesias. Further information on mercury in air pollution was difficult to find, and levels specific for Nova Scotia were not available.

Populations at Risk

Although the entire population will be exposed to varying levels of air pollution there are groups within the population that are at a higher risk for serious health effects. It is important to recognize the high-risk groups and direct appropriate
education and interventions at these groups. The groups identified include, children, elderly, and groups with existing respiratory and cardiovascular diseases. Seniors seem to be at a higher risk for adverse health effects because of increased prevalence of existing medical conditions such as heart conditions, chronic obstructive pulmonary disease to name a few. The presence of many medical conditions can affect the capacity of an individual to deal with increased exposure to pollutants and as a result have a higher likelihood to develop and adverse outcome.

Children are at a higher risk for serious health effects of pollution due to a number of factors. Children’s lungs are not fully developed and during the time they are continuing to grow they are more susceptible to toxins. Children tend to breath more rapidly, and exchange more air per kilogram than adults, thus are exposed to higher levels of pollutants. Children tend to spend more time outside and are more active when they are outside than adults. One of the important risks to children is precipitation of pre-existing asthma and development of asthma like symptoms. Studies have documented dose dependent adverse health effects in response to ambient air quality in children. In a paper from California a greater effect was found with PM2.5 than other components of air pollution. However, Gauderman reported that between two different cohorts differences in effects were noted. Acid vapour was identified as the pollutant that had the most consistent effect on lung function. Consensus agreements state that children in areas of high air pollution will have more adverse health effects. It is not known if this is due to more frequent and severe acute events or chronic exposure. Particulate air pollution has been associated with reduced lung function and growth in children. In studies comparing school absenteeism due to respiratory illness to levels of air pollution, significant association have been found, increased absences from school due to sore throats, coughs and acute asthma events paralleled rises in ozone, or smog, levels. For an increase in concentration of 20 parts per billion, a common day-to-day variation in highly-polluted Southern California, absenteeism for respiratory causes jumped 83 percent.

For the individuals at a higher risk for developing adverse health effects, minimizing exposure to air pollution on days where levels are high is recommended.

Asthma

Example of time-series study demonstrating a relationship between ozone and acute asthma events

Asthma is one of the most common outcomes of air pollution, it is important to understand the relationship between pollutants and acute asthma events. The study discussed here was chosen because of it new data and unique demonstration of the effects of variations of air quality within one region on events related to asthma exacerbations. Disproportionate increases in emissions have occurred in the past few decades due to increased combustion of fossil fuels in automobiles. Atlanta Georgia routinely has ozone levels higher than air quality standards during the summer months. A study published in JAMA in 2001 measured changes in air pollution, metrological conditions and the amount of vehicular traffic in addition to adverse health effects outcomes such as hospitalizations, emergency department visits, and urgent care center visits for asthma during time various time frames. The study concluded that the alternative transportation plan in Atlanta during the Olympic Games reduced ozone and other air pollutants and was associated with a significant, but temporary, decrease in the acute events of asthma among Atlanta’s children. The study looked at the differences in the two time frames and assumed that the Olympics occurred during a time point when there would be dramatic changes in population and vehicular traffic. This study took advantage of the unique opportunity to study the changes in health outcomes that occurred during the changes in emissions. Data on air quality was collected on primary pollutants: PM10, carbon monoxide, nitrogen dioxide, sulfur dioxide, and secondary pollutants: ozone. Information was collected on meteorological data (temperature, wind speed, relative humidity, barometric pressure and solar radiation), hourly traffic
counts, Public transportation usage, and gasoline use. Univariate and multivariate methods were used to analyze the data and the Olympic period was compared to the baseline period. There was a reduction in gasoline use, peak traffic counts by 22.5%, and a greater than 200% increase in the use of public transportation. A reduction of 28% in ozone levels was measured and was correlated with a drop in asthma events ranging from 11% - 44%. This study demonstrated that reductions in ozone and PM10 below air quality standards could reduce adverse health effects when using the example of asthma morbidity in children. It did not seem that there were significant changes in the population of children in Atlanta during the time of this study to account for the reduction in asthma events. A weakness of the study design was the inability to determine the role of other pollutants in the reduction of asthma events. This study supports recommendations for reductions in automobile emissions through changes in commuting habits.

Conclusions

Nearly 8% of non-accidental deaths in Canada can be attributed to pollution produced from the burning of fossil fuels. During times of poor air quality hospital admissions for respiratory illnesses are increased by nearly 6%. Air quality does have a direct effect on human health. Populations identified at a higher risk are children, elderly persons and individuals with pre-existing medical condition. The effects of Air Pollution on health is a huge topic, the information provided in this paper only scratches the surface of the wealth of knowledge available. I hope that the information presented here can be used to educate the public and professionals about air quality issues in Nova Scotia and provide some direction to get more information when needed. Data collection specific for Nova Scotia was difficult to accomplish. There is a need for published yearly reports of air quality monitoring. These reports should focus on trends in the air quality and trend in health of the people in Nova Scotia, hospital admissions, acute respiratory events and deaths should be reported on when there appears to be a link. There is a abundance of primary literature focusing on the health effects of air pollution, it seems that now the next step would be to find dose relationships between the health effects and the levels of pollutants. It would also be useful to have more information investigating the pathophysiology of the effects of many of the common pollutants, so that the biological cause of health effects can be understood and agreed upon. There have been many papers published that study the Epidemiology of air pollution and health, the gap in the knowledge now seems to be a clear understanding of the underlying Pathophysiology. Another issue with the scientific knowledge is the differences between using ambient air quality instead of levels of specific toxins. Both methodologies have advantages and disadvantages. Mounting epidemiological data has shown that air pollution causes adverse health effects, but this has not yet been supported by laboratory or other efforts to understand the underlying pathophysiology. There have not been uniformly accepted threshold levels below which exists no effect on health for many of the air pollutants. There have been some threshold levels set but these have not been agreed upon. Threshold levels for safe levels of exposure need to be determined to enable us to institute changes at the government levels. There needs to be investigation and documentation of attempts and successes to decrease air pollution and emissions with an associated impact on the health of individuals where this is possible. We need data to support the recommendations for reductions in emissions as having a positive impact on individual's health.

Solutions
It has been well recognized that while individuals can do little to reduce air pollution generated that enters Nova Scotia via long range transport it is important that every person do their part in terms of reducing emissions. There are many things that an individual can do to limit their exposure to pollution. Simple strategies include limiting time spent outdoors on days with warnings and limiting strenuous exercise on days with known increases in pollution. Individuals with known lung disease aggravated by increase in pollution may be able adjust the levels of medications that prevent or relieve acute events.

Environment Canada has suggested a list of activities that individuals can do to decrease emission levels. The suggestions include:

- Reduce air conditioning demands in summer by installing window blinds, using ceiling fans and shading your house with trees or awnings.
- Keep your oil or gas furnace properly tuned. A well-maintained unit uses 10 to 15 per cent less energy. Consider replacing old furnaces with a high-efficiency model.
- When shopping for new appliances, compare EnerGuide consumption rates and choose the one that is most efficient. Even if it’s more expensive initially, it will cost less in the long run.
- Wood stoves are available with anti-pollution devices. Choose one of these if you are buying a new wood stove.
- When shopping for a new home, keep energy efficiency in mind. What are the levels of insulation? How efficient is the heating system? Are the windows the best available for reducing heat loss?
- Remember there can be pollution from lawn mowers, snow blowers and outboard motors. Look for low-emission engines.
- Buying new lights? Consider using energy-efficient lighting. Fluorescent bulbs for use in standard incandescent sockets are now available and are more than four times as efficient, and last eight to fifteen times longer than the equivalent incandescent bulb.
- Don’t idle your car engine. Turn it off, even if it’s just for a few minutes.
- Try walking, biking or in-line skating rather than taking your car.

**Summary**

In recent years there has been intense study into the effects of air pollution on human health. Studies documenting exposure to pollutants such as particulate matter and ozone (smog) have demonstrated increases in mortality and hospital admissions due to respiratory and cardiovascular disease. Adverse health effects have been documented for day-to-day variations and in long-term studies that have followed cohorts of exposed individuals over time. A threshold for levels of exposure has not been adequately documented.

- Air pollution is composed of ground-level ozone, particulate matter in varying sizes, carbon monoxide, nitrogen oxides, and sulfur dioxides. Smog is a composition of pollutants and particulate matter and is often used interchangeably with air pollution.
- The air quality index is a measure of 6 common pollutants (Particulate Matter 10 μm (or PM10), PM2.5, ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead), but often tends to be a major reflection of smog.
- Air pollution causes a significant number of deaths and adverse health effects in Canada each year.
- Acute effects of air pollution include: irritation of eyes, nose and throat; exacerbations of existing lung and heart diseases, wheezing, coughing and difficulty breathing. Particulate matter has been associated with increased risk of heart disease.
- Chronic effects include increased mortality, chronic bronchitis, lung cancer, prevalence of asthma.
- The health effects of chronic long-term exposure to low levels of pollution is controversial.
- It is important for each individual to reduce emission in their own life as this can help to decrease the effects of air pollution on their health and the health of their community.

**In Nova Scotia**
Nova Scotia has had levels of ozone and PM2.5 that exceed the National Standards.
Air Quality Issues in Nova Scotia are: smog, acid rain, mercury, and pesticides.
Nova Scotia is the third highest producer of particulate matter due to wood burning in Canada. Wood burning

**Summary of Air Pollutants and know health effects**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Source</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Particulate Matter</strong></td>
<td><strong>Primary Particulate Matter</strong>: Natural sources – fog, dust, smoke</td>
<td>Inspirable particulate mater &lt; 10 microns, remains in air for minutes to hours, and can travel a few hundred meters to as much as 50km</td>
</tr>
<tr>
<td></td>
<td>Human activities – Combustion of fossil fuels, mining &amp; milling, road dust, gaseous emissions</td>
<td>Respirable Particulate matter &lt; 2.5 microns, remains in the air for days to weeks and can travel as far as 800km.</td>
</tr>
<tr>
<td></td>
<td><strong>Secondary Particulate Matter</strong>: Results from chemical reactions in the air with gases and volatile heavy metals</td>
<td></td>
</tr>
<tr>
<td><strong>Ground level ozone (O3)</strong></td>
<td>Interaction of nitrogen dioxides and volatile organic compounds in the presence of light. Formed by the combination of 3 oxygen molecules</td>
<td>Symptoms of chest tightness, shortness of breath, cough, wheeze, pulmonary inflammation, declines in lung function, increases in bronchial hyper reactivity, exacerbations of allergen induced asthma. Development of asthma, increased emergency room visits, increased hospitalizations, and increased mortality rates. Effects of ozone exposure last up to 18hrs following exposure. 1.4% increase in premature death</td>
</tr>
<tr>
<td><strong>SMOG</strong></td>
<td>Fumes from cars, trucks, lawnmowers, boat engines, ATVs and other fuel powered engines, as well as, the emissions from manufacturing plants, dry cleaners and coal or gas-fired power plants.</td>
<td>See ground level ozone</td>
</tr>
<tr>
<td><strong>Nitrogen oxides (eg. NO2)</strong></td>
<td>Combustion of fossil fuel, vehicle emissions, power generation, oil refineries, wood burning. NO2 can combine with water for form nitric acid which contributes to acid rain</td>
<td>Causes irritation to the respiratory system results in coughing, wheezing and shortness of breath. 5.35% increase in premature death</td>
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<tr>
<td><strong>Volatile Organic Compounds</strong></td>
<td>Natural vegetation (main source) – plants and trees</td>
<td>Contribute to the formation of smog and secondary particulate matter</td>
</tr>
<tr>
<td></td>
<td>Human activities: combustion of gasoline, diesel and fossil fuels; solvents and dry cleaning chemicals</td>
<td></td>
</tr>
<tr>
<td><strong>Carbon Monoxide</strong></td>
<td>Energy generation, combustion of hydrocarbons (gasoline)</td>
<td>2.5% increase in premature death</td>
</tr>
<tr>
<td><strong>Sulfur Dioxide</strong></td>
<td>Combustion of fossil fuels</td>
<td>Eye irritation, shortness of breath, decreased lung function, inflammatory changes precipitating asthma 1.8% increase in premature death</td>
</tr>
<tr>
<td><strong>Carbon Dioxide</strong></td>
<td>Natural Sources and Human activity</td>
<td>Headache, drowsiness, arrhythmias, coma, death</td>
</tr>
<tr>
<td><strong>Carbon Monoxide</strong></td>
<td>Combustion and burning of fossil fuels</td>
<td>Drowsiness, coma, death</td>
</tr>
</tbody>
</table>

*Increases in premature death from
Appendix A – Additional Website Resources

Appendix b – Pub Med Search

<table>
<thead>
<tr>
<th>Search</th>
<th>Most Recent Queries</th>
<th>Time</th>
<th>Result</th>
</tr>
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<tr>
<td>#35 Related Articles for PubMed (Select 12512164)</td>
<td></td>
<td>20:05:23</td>
<td>114</td>
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<tr>
<td>#33 Related Articles for PubMed (Select 12000251)</td>
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<td>1016</td>
</tr>
<tr>
<td>#30 Search #26 AND Management</td>
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<td>20:00:30</td>
<td>23</td>
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<tr>
<td>#27 Search #26 AND #2</td>
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<td>14</td>
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<td>#26 Search Outdoor Air Pollution</td>
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<tr>
<td>#25 Search #24 AND #2</td>
<td></td>
<td>19:56:31</td>
<td>1</td>
</tr>
</tbody>
</table>
Sample of search results

1: Omland O.
Exposure and respiratory health in farming in temperate zones--a review of the literature.
PMID: 12498578 [PubMed - indexed for MEDLINE]

2: Weisel CP.
Assessing exposure to air toxics relative to asthma.
PMID: 12194882 [PubMed - indexed for MEDLINE]

3: Meek ME, Beauchamp R, Long G, Moir D, Turner L, Walker M.
Chloroform: exposure estimation, hazard characterization, and exposure-response analysis.
PMID: 12162870 [PubMed - indexed for MEDLINE]

4: Zelikoff JT, Chen LC, Cohen MD, Schlesinger RB.
The toxicology of inhaled woodsmoke.
PMID: 12162869 [PubMed - indexed for MEDLINE]

5: Goldberg MS, Burnett RT, Valois MF, Flegel K, Bailar JC 3rd, Brook J, Vincent R, Radon K.
Associations between ambient air pollution and daily mortality among persons with congestive heart failure.
PMID: 12550083 [PubMed - indexed for MEDLINE]

6: Lin M, Chen Y, Burnett RT, Villeneuve PJ, Krewski D.
Effect of short-term exposure to gaseous pollution on asthma hospitalisation in children: a bi-directional case-crossover analysis.
PMID: 12490649 [PubMed - indexed for MEDLINE]

7: Somers CM, Yauk CL, White PA, Parfett CL, Quinn JS.
Air pollution induces heritable DNA mutations.
PMID: 12473746 [PubMed - indexed for MEDLINE]

8: Wardman AE, Stefani D, MacDonald JC.
Thunderstorm-associated asthma or shortness of breath epidemic: a Canadian case report.
PMID: 12195272 [PubMed - indexed for MEDLINE]
9: Stieb DM, Smith-Doiron M, Brook JR, Burnett RT, Dann T, Mamedov A, Chan Y.
Air pollution and disability days in Toronto: results from the national population health survey.
PMID: 12176005 [PubMed - indexed for MEDLINE]

10: Brook JR, Lillyman CD, Shepherd MF, Mamedov A.
Regional transport and urban contributions to fine particle concentrations in southeastern Canada.
PMID: 12139350 [PubMed - indexed for MEDLINE]

11: Sensen M, Richardson DH.
Mercury levels in lichens from different host trees around a chlor-alkali plant in New Brunswick, Canada.
PMID: 12109479 [PubMed - indexed for MEDLINE]

12: Weis D, Shotyk W, Boyle EA, Kramers JD, Appleby PG, Cheburkin AK.
Comparative study of the temporal evolution of atmospheric lead deposition in Scotland and eastern Canada using blanket peat bogs.
PMID: 12108447 [PubMed - indexed for MEDLINE]

13: Glantz SA.
Air pollution as a cause of heart disease. Time for action.
PMID: 11897433 [PubMed - indexed for MEDLINE]

14: Suwa T, Hogg JC, Quinlan KB, Ghani A, Vincent R, van Eeden SF.
Particulate air pollution induces progression of atherosclerosis.
PMID: 11897432 [PubMed - indexed for MEDLINE]

Effect of motor vehicle emissions on respiratory health in an urban area.
PMID: 11882481 [PubMed - indexed for MEDLINE]

16: Brauer M, Avila-Casado C, Portouli TI, Vedal S, Stevens B, Churg A.
PMID: 11675269 [PubMed - indexed for MEDLINE]

Identification of persons with cardiorespiratory conditions who are at risk of dying from the acute effects of ambient air particles.
PMID: 11544152 [PubMed - indexed for MEDLINE]

18: Jones NL.
[Smoggy days are here again..]
PMID: 11521134 [PubMed - indexed for MEDLINE]

Short-term adverse health effects in a community exposed to a large polyvinylchloride plastics fire.
PMID: 11480504 [PubMed - indexed for MEDLINE]

The association between daily mortality and ambient air particle pollution in Montreal, Quebec. 2. Cause-specific mortality.
PMID: 11386738 [PubMed - indexed for MEDLINE]

The association between daily mortality and ambient air particle pollution in Montreal, Quebec. 1. Nonaccidental mortality.
PMID: 11386737 [PubMed - indexed for MEDLINE]

22: Wolff GT, Dunker AM, Rao ST, Porter PS, Zurbenko IG.
Ozone air quality over North America: part I—a review of reported trends.
PMID: 11256502 [PubMed - indexed for MEDLINE]

23: Goldberg MS, Ballar JC 3rd, Burnett RT, Brook JR, Tamblyn R, Bonvalot Y, Ernst F, Flegel KM, Singh RK, Valois MF.
Identifying subgroups of the general population who may be susceptible to short-term increases in particulate air pollution: a time-series study in Montreal, Quebec.
PMID: 11244610 [PubMed - indexed for MEDLINE]

24: Burnett RT, Smith-Doiron M, Stieb D, Raizenne ME, Brook JR, Dales RE, Leech JA, Cakmak S, Kresvik D.
Association between ozone and hospitalization for acute respiratory disorders in children less than 2 years of age.
PMID: 11226976 [PubMed - indexed for MEDLINE]

Air pollution, aerallergens and cardiorespiratory emergency department visits in Saint John, Canada.


36: Delfino RJ, Murphy-Moulton AM, Burnett RT, Brook JR, Becklake MR. Effects of air pollution on emergency room visits for respiratory illnesses in Montreal, Quebec. Am J Respir Crit Care Med. 1997 Feb;155(2):568-76. PMID: 9032196 [PubMed - indexed for MEDLINE]


62: [No authors listed] Environmental threats to health. Environmental Committee of the Ontario College of Family Physicians.
PMID: 10660800 [PubMed - indexed for MEDLINE]

63: Campbell ME, Benson BA, Muir MA.
Urban air quality and human health: a Toronto perspective.
PMID: 8566685 [PubMed - indexed for MEDLINE]

The nature and origins of acid summer haze air pollution in metropolitan Toronto, Ontario.
PMID: 8187741 [PubMed - indexed for MEDLINE]

1: Vacek L.
Is the level of pollutants a risk factor for exercise-induced asthma prevalence?
PMID: 10209684 [PubMed - indexed for MEDLINE]

2: Kerigan AT, Goldsmith CH, Pengelly LD.
PMID: 3717771 [PubMed - indexed for MEDLINE]

1: Abelsohn A, Stieb D, Sanborn MD, Weir E.
Identifying and managing adverse environmental health effects: 2. Outdoor air pollution.
CMAJ. 2002 Apr 30;166(9):1161-7.
PMID: 12000251 [PubMed - indexed for MEDLINE]

References

Reference List


Ref Type: Report


Ref Type: Serial (Book,Monograph)
