

Outdoor Air Quality

A Primer for B.C. Physicians and Resource for Informing Patients

PURPOSE

Air pollution affects the health of British Columbians.¹⁻⁴ Despite significant progress, air quality remains sub-optimal in many parts of the province. Its health effects have been demonstrated repeatedly even in areas where air quality is commonly thought to be good.

This primer provides a synthesis of current medical understanding of outdoor air pollutants. It aims to update physicians on the major health effects of air pollution on British Columbians and assist them in responding to patient concerns on the issue. It is not intended as a tool for patient management.

This primer is also available in an electronic version at <http://www.bc.lung.ca/pdf/appendix-guide.pdf>, where links to all references and appendices can be found. The appendices provide detailed information on the Air Quality Health Index and Air Quality Advisories.

OVERVIEW - Outdoor Air Pollution: 9 Key Points

This overview is intended as a quick reference for topics covered in this primer. For a more thorough discussion, see the inside pages.

What is air pollution? Where does it come from? How is it measured?

- 1 Air pollutants include gases and particles, which can be harmful to human beings or the environment. Primary air pollutants are those directly emitted to the atmosphere. Secondary air pollutants like ozone are formed in the atmosphere from reactions involving other pollutants.
- 2 Levels of air pollutants vary over time and based on proximity to source/s. They are influenced by weather, topography and emission rates. Local sources, such as outdoor burning, smokestacks, or traffic on major roads, can increase the exposure levels of individuals.
- 3 Air pollution monitors routinely measure a limited number of "indicator" gases and particles. They are typically sited to identify regional pollutant concentrations and/or to reflect the impact of specific sources.

What are the health effects of air pollution?

- 4 Long-term exposure to air pollutants can lead to cardiovascular and respiratory effects. In addition, exposures as brief as hours or days can precipitate sudden respiratory and cardiac illnesses or even death. Air pollutant exposure has also been linked to pre-term birth, low birth weight, acute respiratory infections and otitis media in children.

What is the health burden of air pollution for B.C. residents?

- 5 Studies have linked long-term exposure to current levels of air pollution in B.C. to various diseases and premature death. Additionally, higher daily pollution levels have been

associated with slightly higher death counts over the short term.

Recommendations

- 6 Health is protected over both the long and the short term by living in a community with low levels of air pollution, working and living away from local sources (including traffic), and having clean air indoors.
- 7 Air pollution triggers can be mitigated by avoiding local sources, choosing climate-controlled indoor spaces, and avoiding strenuous physical activity when broadcast pollutant levels are high or when near significant sources of pollution, such as major roads.
- 8 Controlling underlying cardiac and pulmonary diseases decreases the effects of air pollutants. As for supplements, small scale studies show that Omega-3 fatty acids and Vitamins C and E, limit the adverse cardiovascular and respiratory effects of exposure to higher levels of air pollution. *However, there are currently no established recommendations for the routine use of specific dietary supplements to prevent the effects of air pollution.*

Public air quality advice

- 9 The Air Quality Health Index is a tool that indicates the immediate risk to health of current and near-future levels of monitored air pollutants. The B.C. Ministry of Environment and Metro Vancouver issue advisories when individual air pollutants reach threshold levels of concern.

- **Air pollution** is the presence in the air of gases or particles, which are potentially harmful to human health or the environment. Levels of air pollutants vary by proximity to sources, and are influenced by topography, weather, as well as local, regional and even global factors. Some air pollutants like ozone are formed by the reaction of primary pollutants with sunlight, heat, water vapor, other atmospheric constituents and each other.
- **Common air pollution sources** are transportation (such as motor vehicles, marine vessels, rail, aircraft), outdoor burning, space heating (for instance, from wood stoves), industry and construction equipment.
- **Air quality monitors** are typically sited either to represent concentrations of air pollutants within a region or to measure the impact of a particular source, such as a large traffic corridor or major industry. Within a region, air pollution concentrations may vary substantially, influenced by source proximity and topography. Regular monitoring of air quality^{6,7} is conducted throughout B.C. by the B.C. Ministry of Environment and by Metro Vancouver within the Greater Vancouver area. For information on specific air pollutants and their concentrations, see: <http://www.bcairquality.ca> and <http://www.metrovancouver.org/services/air/monitoring/Pages/airqualityindex.aspx>. Environment Canada also produces air quality forecasts up to 2 days ahead; see: http://www.msc-smc.ec.gc.ca/aq_smog/aqcurrent_e.cfm



The **Air Quality Health Index⁸ (AQHI)** is a tool recently introduced to indicate the immediate risk to health of current and near-future levels of three monitored air pollutants. The B.C. Ministry of Environment issues Air Quality Advisories⁶ when specific air pollutants reach threshold levels of concern. Because the AQHI is an ongoing informational tool, and the AQ Advisories a means to encourage action in the face of higher levels of specific pollutants, the health messages they offer at any given time may not be entirely consistent.



- **Commonly monitored outdoor pollutants⁵ include particulate matter (PM), with aerodynamic diameter $\leq 10 \mu\text{m}$ (PM_{10}) and $\leq 2.5 \mu\text{m}$ ($\text{PM}_{2.5}$), or fine particulate matter, ozone, nitrogen oxides, sulphur dioxide, and carbon monoxide.** These pollutants are commonly monitored because they are associated with a range of respiratory, cardiac and other health effects, in addition to having an environmental impact.
- **Pollutant concentrations are important because they characterize air quality between locations and over time, determine the impact of specific sources, and indicate the success of measures to control emissions.** Concentrations are compared to provincial and national air quality objectives*.
- **"Air toxics,"** such as certain metal dusts and organic compounds, also pose a risk, especially around point sources, but they are not monitored routinely.

* For a list of current air quality objectives, see: <http://www.bcairquality.ca>

What are the health effects of air pollution? 4

Epidemiologic studies of long-term (months to years) exposure to air pollution show increases in relative risk of death from lung cancer and cardiopulmonary diseases.^{10,11,15,16} Depending on the study, exposure estimates were based on measured or modeled levels of traffic, ozone or PM. Here's a summary of the findings on long-term exposure.

Long-term exposure results in:

- Accelerated development of atherosclerosis^{17,18}
- Increase in systemic inflammatory markers^{19,20}
- Impaired lung development in children²¹⁻²⁴
- Increased incidence of asthma and asthma exacerbations²⁵⁻³¹
- More frequent pre-term births and low birth weight babies³²⁻³⁷
- Increased rates of otitis media^{38,39}

Over the short term (hours and days to weeks), air pollution has been associated with increased hospitalizations and/or deaths due to cardiovascular and respiratory causes.^{12,13,14} In general, respiratory effects and cardiovascular effects have been associated with exposure to ozone and PM respectively. Here's a summary of the findings on short-term exposure.

Short-term exposure results in:

- Increased rates of myocardial infarction in those with risk factors for cardiovascular disease⁴⁰⁻⁴²
- Increased incidence of cardiac arrhythmia^{43,44}
- Exacerbation of obstructive respiratory illness (e.g. asthma⁴⁵⁻⁴⁸ and COPD⁴⁹⁻⁵¹)
- Respiratory inflammation and irritation⁵²⁻⁵⁴
- Reduced lung function⁵⁵⁻⁵⁷

Individuals react to air pollution differently. At the population level, it does not look like there is a no-effect threshold level for air pollution.^{58,59} Although for most people, air pollution may be a relatively minor risk, especially over the short term, studies of large populations indicate measurable health effects on susceptible individuals and substantial public health impacts. Increased exposure has been linked to increased risk. Controlling underlying cardiac and pulmonary diseases decreases the effects of air pollutants.



FACTS

Pollutants and staying indoors

- Indoor air concentrations of some pollutants like ozone are lower.⁷¹
- Some outdoor pollutants efficiently penetrate indoors. For PM, this is a function of the tightness of the building.⁷²
- Indoor pollutant sources can be significant (e.g., tobacco smoke, PM from improperly ventilated cooking space, volatile organic compounds from furniture or cleaning materials, and mould).⁷¹
- Indoor air quality needs to be protected through proper ventilation and limiting the sources of indoor pollutants.
- Staying indoors in hot weather, while a good way to avoid pollutants, may also produce adverse effects from heat.

What is the health burden of air pollution for B.C. residents? 5

The burden of air pollution is computed based on both measurements and estimates of exposure as well as on equations which relate exposure levels to health effects. The 2003 B.C. Annual Report of the Provincial Health Officer offered a series of estimates of annual mortality ranging from 25 to 644 air pollution-related deaths⁷⁶. "Mid-point" estimates included 712 hospital admissions and 994 emergency department visits per year for B.C. as a whole. A 2008 Canadian Medical Association estimate for B.C. projected 306 premature deaths (of which 85% relate to long-term and 15% to short-term exposure), 1,158 hospital admissions, 8,763 emergency department visits and 2,526,900 minor illnesses related to air pollution during 2008⁷⁷.

Recommendations 6 7 8

While over the short term some individuals (especially young children, pregnant women and those with cardiac and respiratory disease or diabetes) are more susceptible to the effects of air pollutants, the general population will also benefit from the recommendations below.

WAYS TO LOWER EXPOSURE OUTDOORS

- Commuting is a significant means of air pollution exposure. The highest pollutant concentrations are along major roads. When possible, individuals should limit the time they spend commuting to reduce exposure⁶⁰ and/or to lessen the amount of pollution they generate, if they drive a vehicle.
- When considering where to live and work, people should choose a location which is more than 150 meters away from major roads.⁶¹ High pollutant concentrations can be found up to 750 meters from truck routes.
- Patients should be assisted in finding a “clean air shelter” in their community during wintertime inversions, forest fires and similar circumstances. Examples of these shelters are air conditioned spaces (like shopping malls) with medium- or high-efficiency air filtration or a room with a HEPA filter air cleaner.



THINGS TO KNOW ABOUT MEDICATION AND DIET

- Optimal use of cardiac and respiratory medications based on individual clinical parameters offers protection, given acute exposure to particulates and ozone.^{64,65}
- Small scale studies show that Omega-3 fatty acids and Vitamins C and E, taken as supplements, limit the cardiovascular and respiratory effects of exposure to higher levels of air pollution.⁶⁶⁻⁷⁰ *However, there are currently no established recommendations for the routine use of specific dietary supplements to prevent the effects of air pollution.*

FACTS

Pollutants and times of day

THINGS TO KNOW ABOUT INDOOR SPACE

- Indoor spaces with central air conditioning limit exposure to outdoor pollutants.
- Installing HEPA filters in forced air furnaces will reduce indoor exposure to particles.
- Stand-alone air cleaners can improve air quality,^{62,63} but it is important to select non-ozone generating models. For a list of air cleaners which should be avoided, see <http://www.arb.ca.gov/research/indoor/o3g-list.htm>.
- Indoor air quality should be protected by properly ventilating cooking spaces, reducing emissions from heating, eliminating tobacco smoke and mould remediation.



- Concentrations of many pollutants fluctuate throughout the day.
- Patterns are different for different pollutants.
- Ozone is generated by the action of sunlight on air pollutants and generally peaks in the late afternoon.
- PM, NO₂ and other traffic-related emissions are higher during rush hours, especially in the morning.^{73,74}
- Wood smoke level is at its highest in the evening and at night.⁷⁵
- Different times of day will have different pollutant mixtures that individuals may wish to avoid.

LIMITING OUTDOOR EXERCISE

- During active exercise, both the rate and depth of respiration increase. Respiratory impacts can be avoided or limited by exercising earlier during the day, when ozone concentrations tend to be lower, and as far away as possible from roads, factories and smoke. The potential benefits of restricting exercise to certain times and places need to be weighed against the health benefits that exercise offers.

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APPENDIX

A GUIDE

**AIR QUALITY
INFORMATION**

FOR THE PUBLIC

Information on air quality is disseminated to the public primarily through Air Quality Advisories during periods of poor air quality and the ongoing Air Quality Health Index. Both are described in the following pages.

Air Quality Advisories

What are Air Quality Advisories?

- Air Quality Advisories are issued by the B.C. Ministry of Environment and Metro Vancouver to inform the public of degraded air quality and to trigger actions (e.g., burn bans, reduction in wood stove use) to prevent or reduce emissions.
- Advisories are issued when measured air pollution levels approach or exceed defined trigger thresholds based on established national or provincial air quality objectives.
- Outdoor air quality objectives have been established for particulate matter (PM), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide.¹ The objectives incorporate considerations to protect both people and the environment.
- Historically, these objectives were used to calculate Air Quality Index (AQI), a number representing the value of a single pollutant with the highest concentration relative to its outdoor air quality objective.
- The AQI continues to be available for B.C. communities, although the B.C. Ministry of Environment is promoting alternatives to the AQI such as improved public access to **real-time air quality concentrations** for all monitored pollutants, and the **Air Quality Health Index (AQHI)** in the most populated areas of the province.
- Although elevated levels of any of the above pollutants may trigger an air quality advisory, the vast majority of such events in B.C. have resulted from high particulate matter (PM) concentrations. The exception is in the Lower Fraser Valley, where ozone has been the main cause for air quality advisories.
- The number of advisories issued each year varies across the province. For example, between 2003 and 2007, PM-related advisories were issued a total of 28 times (69 days total) in Prince George. In contrast, four ozone-driven advisories and one PM-driven advisory were issued in the Lower Fraser Valley during the same period.

How are Air Quality Advisories issued?

- Air quality meteorologists review current air quality levels along with current and forecast meteorological conditions to assess the expected severity and duration of an air pollution event.
- This information is used together with local knowledge of sources and air dispersion to determine if an advisory should be issued.

How are Air Quality Advisories used?

- Air Quality Advisories may include voluntary and mandatory actions to effect a reduction in emissions.
- Voluntary measures include asking the public to take alternative forms of transportation other than single occupancy vehicles.
- Mandatory actions include burn bans pursuant to the **Open Burning Smoke Control Regulation** and bans or restrictions on wood stove use and backyard burning as required by local bylaws.
- Health messages have traditionally accompanied Air Quality Advisories. However, health effects can occur at pollutant concentrations below those which trigger advisories.



¹ For a listing of current air quality objectives, see: <http://www.metrovancouver.org/services/air/monitoring/Pages/airqualityindex.aspx>.

Air Quality Health Index

Basic information

- The AQHI is a new measure of air quality developed by Health Canada, Environment Canada and a variety of provincial, municipal, health and non-government stakeholders.
- It integrates the effects of three commonly monitored pollutants, namely nitrogen dioxide, ozone, and particulate matter (PM_{2.5}).²
- Air quality is displayed on a scale of 1 to 10+, with index results presented within categories of risk to health (Low, Moderate, High or Very High Health Risk).
- The scale is based on a [study](#) that evaluated increases in daily mortality following short-term fluctuations of pollutants measured in major Canadian cities.⁹
- In British Columbia, ozone and nitrogen oxide levels are generally quite low (with some exceptions).³ This means that the AQHI (based on these two pollutants plus PM) may sometimes be low despite high PM levels or the presence of visible haze.
- The calculation of near real-time AQHI reports and short-term forecasts relies on a continuous air monitoring network that provides hourly concentrations of pollutants.
- The monitoring network is currently available in some British Columbia communities (see airhealthbc.ca or airhealth.ca), including all major centres and covering 80% of the provincial population.
- Air pollution is a risk factor for adverse birth outcomes, such as pre-term birth and low birth weight babies. However, this is more likely due to long-term exposure than to the short-term fluctuations that are reflected in the AQHI.

Using the AQHI in patient care

There is little direct evidence at this time that short-term behaviour change can limit health outcomes related to air pollution exposure. Physicians should therefore view the AQHI as an opportunity to reinforce messages of basic symptom management and pollution avoidance as well as a tool to support patients in pro-

tecting themselves when the AQHI reaches high levels. Points for discussion are suggested below:

- Patients with cardiovascular risk factors or established cardiac or obstructive respiratory disease are at higher risk for adverse effects related to air pollution.
- Patients with chronic respiratory or cardiac health conditions (or risk factors) who are on appropriate medications are relatively resistant to the effects of pollutants.
- Individuals' exposure to air pollution will vary by their location and activity. Individuals can limit exposure by avoiding emissions (such as on busy roads and downwind of industrial facilities) at all times, independent of the AQHI level.
- Exercise increases exposure to air pollutants due to increased volumes of inhaled air and deeper inhalation, which results in more distal pollutant deposition in the lungs. With AQHI values 4 or higher, susceptible individuals are advised to reduce their short-term risk of air pollution health effects by restricting exercise to an indoor space with clean air.
- Susceptible patients may wish to identify a "clean air shelter" in their community for use as the AQHI approaches or is forecast at value 7 or higher (infrequent in most B.C. communities). This should be an indoor space with central air conditioning.
- While outdoor air quality is reflected in the AQHI, indoor air quality is also important. Thus, patients should eliminate indoor sources, such as tobacco smoke, and limit outdoor pollutant entry through the use of HEPA filters and central air conditioning.
- Responses to a given concentration of air pollutant/s and/or AQHI level will vary between individuals and over time within the same individual.
- Although the AQHI focuses on short-term health outcomes, long-term exposure to pollutants is estimated to cause three times as many deaths as short-term fluctuations. Everyone has a role to play in reducing emissions and working for clean air every day to reduce long-term exposures.

² Particles less than 2.5 micrometers in diameter

Comparing BC Air Quality Advisories and the new Air Quality Health Index (AQHI)

Air Quality Advisories	Air Quality Health Index
Issued by the B.C. Ministry of Environment/Metro Vancouver in response to high levels of measured individual air pollutants	An air quality information tool developed by Health Canada/Environment Canada and partners based on a Canadian epidemiologic study relating numbers of daily deaths to same day levels of three pollutants: nitrogen dioxide, ozone, and particulate matter
Issued in more than 35 communities throughout B.C., including the Lower Mainland	Available in Prince George, Quesnel, Kamloops, Vernon, Kelowna, Nanaimo, Victoria, Whistler and Williams Lake, and throughout Metro Vancouver and the Fraser Valley
Only issued when air pollution approaches or exceeds specific trigger levels	Calculated on an ongoing basis; the AQHI scale (0-10+) represents increasing levels of air pollution-related risk to health
Incorporates general health messaging around pollution avoidance, especially for vulnerable persons	Health advice keyed to index level separately for general population and specific vulnerable groups
May trigger voluntary or mandatory actions to reduce emissions	Triggers no specific actions: currently an information tool only

Frequently Asked Questions on Air Quality Advisories and the Air Quality Health Index

1. It's a hazy day, but the AQHI says air quality is a low health risk. What do I tell my patients?

Haze is often due to fine particulate matter (PM) and moisture in the air, and PM is but a minor contributor to the overall index. Because of this, a hazy day may not trigger an increase in the AQHI despite the presence of pollutants in the air. Conversely, a high AQHI level may not be accompanied by reduced visibility.

2. The AQHI is at "low health risk," but the B.C. Ministry of Environment has issued an Air Quality Advisory. What do I tell my patients?

The B.C. Ministry of Environment will continue to issue Air Quality Advisories as it has in the past. These are calculated in a different manner from the AQHI. Advisories are triggered when individual pollutants approach or exceed established national or provincial air quality objectives (comparable to national Maximum Acceptable Levels). Advisories are issued

to protect the environment and to encourage citizens to take actions to reduce emissions. Health messages have traditionally accompanied these advisories because, in general, health effects increase as air quality worsens. Despite the low AQHI, patients should follow recommendations outlined in the advisories.

3. If the AQHI is based on mortality, how can it predict symptom exacerbation?

The link between the AQHI and predicted worsening of patient symptoms can only be assumed on the basis of data on increased mortality. However, other studies have linked increased symptoms to increased air pollution.

4. My patient lives close to a busy road. Will the AQHI reflect his/her exposure?

Only in part. The AQHI reflects regional estimates of short-term air quality based on fixed monitoring

stations, but individual exposure will vary based on proximity to high-pollution areas. Long-term exposure to sources of pollutants can significantly impact a patient's health independent of AQHI levels. Patients, particularly those with cardiovascular or obstructive respiratory disease who live near a significant source of air pollutants such as busy roads may wish to protect their indoor air by using a central air conditioner or HEPA filters.

5. Does the AQHI reflect the air pollution mix in British Columbia?

The AQHI is based on a study using air quality measurements in large cities across Canada, including Vancouver. In the pooled results, health effects correlated most strongly with nitrogen dioxide (NO₂) levels, which is reflected in the AQHI calculation. In most of British Columbia, however, NO₂ concentrations are low and particulate matter is a much more

significant pollutant. In many places in B.C., especially outside of highly urbanized areas, it is likely that the AQHI will not correlate well with high PM levels.

6. What are appropriate physical activity recommendations?

Messages linked to the AQHI advise sensitive individuals to begin reducing outdoor activities at value 4 on the AQHI scale. The risks of exposure to outdoor air pollutants and of physical inactivity should be balanced and all patients should be encouraged to be as physically active as possible.

Keep in mind that outdoor air quality is only one of the contributors to individual patient symptoms. Patients should respond to increased symptoms as they normally would (e.g., by using rescue medications and/or reducing activity). They may also wish to check the AQHI to see if poor air quality could be contributing to their current symptoms.



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