Medical Summary

AIR POLLUTION AND THE INTERNATIONAL TRAVELER

Environmental pollution has become a cause of increasing concern for travelers and expatriates. In 2012, WHO estimated 7 million deaths worldwide were attributed to air pollution, including 3.7 million due to outdoor air pollution and 4.3 million due to indoor air pollution (some deaths may have been caused by both types of pollution, so 7 million is an estimate). Levels of air pollution have been increasing significantly in low- and middle-income countries, especially in South Asia. See below for recommendations on risk assessment and prevention.

AIR POLLUTION AS AN INTERNATIONAL ISSUE

Air pollution, whether outdoor or indoor, may directly affect the health of travelers and expatriates.

Outdoor air pollution in urban areas occurs primarily due to motor vehicle emissions (carbon monoxide [CO], carbon dioxide [CO_2], nitric acid, benzene, particulate matter) and power and heat generation (soot/particulate matter and sulfur dioxide (SO_2) from soft coal combustion and industrial power generation). Wind-blown dust also contributes to pollution.

Indoor cooking and heating with biomass fuels or coal produces indoor smoke that impairs health. Nitrogen dioxide (NO_2) is generated from indoor cooking and heating with gas. Other indoor pollutants can include radon (Rn), asbestos, lead (Pb), formaldehyde, pesticides, respirable particles and environmental tobacco smoke (ETS), biologicals (pollen, fungi, dust mites, etc.), CO, and organic gases (paint, solvents, aerosols, disinfectants, etc.). Even in Europe, ventilation levels may not reach U.S. standards, and recent increases in trekking and adventure travel have brought the issue of indoor cooking to the attention of travelers. This issue is particularly important in China, where indoor air pollution levels are increased greatly during periods of indoor cooking with inadequate ventilation. In addition, air toxics and allergens are more common from indoor air in developing countries.

HEALTH EFFECTS OF AIR POLLUTION

Air pollution adversely affects the cerebrovascular, cardiovascular, and respiratory systems. Primary air pollutants—including particulate matter (PM; composed mainly of sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water), NO_2, SO_2, ozone, CO, and Pb—and air toxics have become international issues.

The U.S. Environmental Protection Agency (EPA) has published summaries of evidence for health and environmental effects of these 6 “criteria” pollutants (PM, NO_2, SO_2, ozone, CO, and Pb) and has set National Ambient Air Quality Standards. Importantly, exposure to particulate matter measuring 10 µ in diameter or less (PM_{10}) clearly increases risk for cardiovascular and respiratory diseases and leads to increased mortality morbidity; fine particles measuring 2.5 µ in diameter or less ($PM_{2.5}$) are especially damaging to health. (See Table 1, below.) The EPA’s daily Air Quality Index (AQI) serves as a parameter to modify health risk.

Table 1: Air Quality Index (AQI) and 2005 WHO air quality guidelines and effects from excess concentrations of pollutants

Indicator	Guideline values	Health effects
Air Quality Index (U.S. EPA)		
	0-50 (Good)	Air quality is considered satisfactory, and air pollution poses little or no risk.
	51-100 (Moderate)	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
	101-150 (Unhealthy for sensitive groups)	Air quality is frequently unhealthy for members of sensitive groups (people with lung or heart disease, adults aged ≥ 70 years, teenagers, or children). Members of sensitive groups may experience health effects. The general public is not likely to be affected. Members of sensitive groups should reduce prolonged or heavy outdoor exertion.
	151-200 (Unhealthy)	Air quality is frequently unhealthy. All travelers may begin to experience health effects. Members of sensitive groups (people with lung or heart disease, adults aged ≥ 70 years, teenagers, or children) may be more seriously affected. Members of sensitive groups should avoid prolonged or heavy outdoor exertion. Others should reduce prolonged or heavy outdoor exertion.
	201-300 (Very unhealthy)	Air quality is frequently very unhealthy. All travelers are likely to experience health effects. Members of sensitive groups (people with lung or heart disease, adults aged ≥ 70 years, teenagers, or children) should avoid all outdoor physical activity except at times when air quality is better. Others should avoid prolonged or heavy outdoor exertion and consider postponing such activities until air quality is better.
	301-500 (Hazardous)	Air quality is frequently hazardous. All travelers are likely to experience serious health effects. Members of sensitive groups (people with lung or heart disease, adults aged ≥ 70 years, teenagers, or children) should remain indoors and keep activity levels low. Others should avoid all outdoor physical activity and postpone such activity until air quality is better.
Specific pollutants (WHO 2005)		**Health effects from excess pollutants**
Particulate matter (PM_{10})	20 µg/m3 annual mean; 50 µg/m3 24-	Lodge inside lungs, lead to cardiovascular diseases (including MI, sudden cardiac death, arrhythmia, CHF exacerbation, and stroke) and respiratory diseases (including acute lower respiratory infections, exacerbation of asthma/COPD, and lung cancer).

	hour mean	
Particulate matter ($PM_{2.5}$)	10 µg/m3 annual mean; 25 µg/m3 24-hour mean	Same as above
Ozone (O_3)	100 µg/m3 8-hour mean	Breathing problems, asthma exacerbation, reduced lung function, causes lung disease.
Nitrogen dioxide (NO_2)	40 µg/m3 annual mean; 200 µg/m3 1-hour mean	Airway inflammation, bronchitis.
Sulfur dioxide (SO_2)	20 µg/m3 24-hour mean; 500 µg/m3 10-minute mean	Impaired pulmonary function, inflammation of respiratory tract, irritation of eyes.

GEOGRAPHIC DETERMINANTS OF AIR POLLUTION RISK

The major cities of Asia, in particular South Asia, have had dramatically increased pollution levels since the early 2000s and are currently considered the most polluted globally. (See Table 2, below.) Cities in India (Delhi, Gwalior, Rajpur, Lucknow, Agra, Amritsar) and Pakistan (Peshawar, Rawalpindi, Karachi) have the world's highest annual mean PM_{10} concentrations, with Chinese cities not far behind. In China, aside from some cities where natural or liquid petroleum gas is available, coal is the major source of energy, producing high levels of SO_2 and particulate matter indoors. Beijing has a significant particulate problem due to the continued use of brown coal (although its use is declining), and the existing particulate pollution is dramatically increased by the loess—fine particulate matter blown in by the wind from the Gobi Desert. Particulate problems are exacerbated by other phenomena such as forest clearing by burning. In some cities in the region, burning has led to extremely high particulate levels—high enough to necessitate evacuation of multinational expatriates and to restrict visitors with underlying cardio-pulmonary disease.

Air pollution is not confined to Asia, however; central and eastern Europe have significant levels of all primary pollutants, and particulates and air toxics are of concern due to limited emissions controls. Air pollution is a significant problem in Russia. Mediterranean countries lag behind northern Europe in pollution reduction (e.g., Athens, Greece has a significant NO_2 problem), but even northern Europe can experience high particulate levels during the summer months.

Pollution related to regular thermal inversions plagues the entire Pacific coast of the Americas from Los Angeles, U.S., to Santiago, Chile.

Data are unavailable for many countries of Africa, but major cities such as Accra, Ghana, Dakar, Senegal, and Johannesburg, South Africa have annual mean PM_{10} and $PM_{2.5}$ concentrations rivaling some Asian counterparts. (See Table 2.) In sub-Saharan Africa, the harmattan winds blow desert sands over many major cities and frequently combine with air pollution from other sources.

In the Middle East, sandstorms are common and often necessitate respiratory protection; the combination of dust and extreme heat (up to 120-130°F; 40-55°C) can lead to significant health risks. Several cities in the Middle East (including Abu Dhabi, UAE; Doha, Qatar; Amman, Jordan) also have highly hazardous PM_{10} concentrations.

Table 2: Ranking of selected major cities' PM_{10} and $PM_{2.5}$ concentrations

At PM_{10} > 102 and/or $PM_{2.5}$ > 22, people with lung disease and those at extremes of age should avoid prolonged or heavy outdoor exertion, and everyone else should limit prolonged or heavy outdoor exertion. Higher PM_{10} and $PM_{2.5}$ concentrations mandate more severe restriction.

City	Country	Annual mean PM_{10} (µg/m^3 annual mean)	Annual mean $PM_{2.5}$ (µg/m^3 annual mean)
New Delhi	India	286	153
Abu Dhabi	UAE	170	64
Mumbai	India	136	45
Cairo	Egypt	135	73
Beijing	China	121	56
Johannesburg	South Africa	98	51
Kolkata/Calcutta	India	97	43
Tianjin	China	96	44
Mexico City	Mexico	93	25
Shanghai	China	79	36
Santiago	Chile	69	26
Rio de Janeiro	Brazil	67	36
Tel Aviv	Israel	67	23
Antalya	Turkey	63	42

Lima	Peru	63	38
Ho Chi Minh City	Vietnam	58	27
Shenzhen	China	57	26
Manila	Philippines	49	22
Seoul	South Korea	49	22
Istanbul	Turkey	48	32
Bogotá	Colombia	48	27
Jakarta	Indonesia	48	21
Hong Kong	China	45	21
Bangkok	Thailand	38	20
Milan	Italy	37	33
Kuala Lumpur	Malaysia	36	17
São Paulo	Brazil	35	19
Warsaw	Poland	35	26
Montreal	Canada	34	11
Budapest	Hungary	33	27
Moscow	Russia	33	22
Los Angeles	United States	33	20
Rome	Italy	32	21
Athens	Greece	30	22
Buenos Aires	Argentina	30	16
Cape Town	South Africa	30	16
Lisbon	Portugal	28	14
Vienna	Austria	27	19
Geneva	Switzerland	27	18
Montevideo	Uruguay	27	18
Brussels	Belgium	27	18
Singapore	Singapore	27	17
Frankfurt	Germany	26	19
Prague	Czech Republic	26	19
Amsterdam	Netherlands	25	18
Hamburg	Germany	25	17
Barcelona	Spain	25	16
Berlin	Germany	24	20
Paris	France	24	17
Toronto	Canada	24	8
Bonn/Cologne Region	Germany	23	17
Atlanta	United States	23	14
New York City	United States	23	14
Oslo	Norway	23	13
London	United Kingdom	22	16

Chicago	United States	22	13
Madrid	Spain	22	11
Tokyo	Japan	22	10
Munich	Germany	21	14
Houston	United States	21	13
Osaka-Kyoto	Japan	21	10
Zurich	Switzerland	20	14
Dallas	United States	20	12
Washington, D.C.	United States	19	12
Melbourne	Australia	18	5
Boston	United States	16	10
San Francisco	United States	16	10
Seattle	United States	16	10
Auckland	New Zealand	15	7
Stockholm	Sweden	15	7
Miami	United States	14	8
Copenhagen	Denmark	12	17
Orlando	United States	12	7
Canberra	Australia	12	7
Vancouver	Canada	11	4
Sydney	Australia	9	5

ASSESSING RISK

Although there is growing awareness of the risk from air pollution in many travel destinations, clear guidelines for the prevention of symptoms or disease have not been developed. In order to adequately advise the traveler, travel health providers must assess the potential risk to the traveler based on the extent of the air pollution in the planned destination, duration and timing of the trip, underlying health conditions of the traveler, and medical resources available at the destination. The combination of increased risk, inadequate medical facilities, and limited access to English-speaking physicians in many developing countries is particularly challenging.

While anyone can be affected by air pollution, those at increased risk of health problems resulting from air pollution may include those with chronic diseases, the older or very young traveler, and the adventure traveler. In these cases, and particularly for those chronic diseases, the duration of the trip or expatriation combined with the level of personal exposure will determine what, if any, long-term risks exist. If the combination of increased risk of air pollution and underlying risk of the traveler causes concern, management strategies must be developed.

First, an appraisal of environmental exposure must be made of both outdoor and indoor air pollution. Travax destinations should be checked for countries with extreme air pollution issues. The following data sources on air quality and particulate matter concentrations can guide estimates for many individual cities:

- International air quality website: http://airnow.gov/index.cfm?action=airnow.international
- Air quality index visual map: http://aqicn.org/map/world
- WHO country PM_{10} data/map: http://gamapserver.who.int/gho/interactive_charts/phe/oap_exposure/atlas.html
- WHO database on PM_{10} and $PM_{2.5}$ for cities from 2014: http://apps.who.int/gho/data/view.main.AMBIENTCITY2014?lang=en (see Table 2)

Next, the underlying risk of disease or disease exacerbation for the traveler or expatriate must be assessed. The exacerbation of preexisting respiratory or cardiovascular disease (such as asthma, COPD, pulmonary fibrosis, or congestive heart failure) and the acute health effects from respiratory, mucous membrane, or eye irritation must be considered for all travelers and expatriates. Adequate oxygenation may be affected by multiple environmental factors including altitude and pollution levels.

Other health background may need to be addressed. For example, a traveler who usually wears contact lenses should be advised to bring regular eye glasses, if she or he will be in an area of heavy dust and ozone.

In order to advise the traveler, the travel health provider must integrate the likelihood and duration of exposure during the trip, possible methods to reduce the levels of exposure, underlying risk of disease or exacerbation of disease, and medical resources available.

GENERAL RECOMMENDATIONS

Assess the traveler's fitness for travel to destinations with high-level air pollution, with particular attention to cardiovascular and respiratory health.

Persons with asthma, chronic obstructive pulmonary disease, or heart disease, and children and older adults are most vulnerable to ill health effects from air pollution.

Assess the possibility of exposure to indoor cooking or heating with biomass fuels, kerosene or coal in a poorly ventilated environment.

Discuss with the traveler effective ways to reduce or avoid exposure, such as the best time of day for outdoor exercise (air pollution levels are lower in the early morning;

thus those who exercise outdoors should be advised to do so early in the day) and the times of the year when outdoor air quality is least affected by pollution in areas where there is local variability.

For travelers to highly polluted cities, discuss the use of face masks, as these are often quite popular among the local population in affected areas. No scientific evidence supports a salutary effect of any kind of mask in mitigating the effects of pollution on health. Masks labeled as N95 respirators are, in theory, most likely to be effective, because they should filter most small particulates. However, masks must fit properly to make an effective seal and are difficult to wear properly for any period of time. When worn properly, the work of breathing is increased, a problem for those with underlying respiratory compromise. Masks do not filter gases such as ozone, nitrogen dioxide, or sulfur dioxide.

If an underlying health problem exists, assure that treatment is stabilized before travel commences. Advise that all medications the patient currently takes or has taken in the last 12 months are carried on the trip (such as inhalers for asthmatic travelers) and provide the traveler with the necessary documentation for those medications (e.g., a medication letter to be used in customs).

Provide the traveler with the name of a physician and/or hospital that can treat the traveler effectively and safely at destination.

Advise the traveler on the possible need for health and/or evacuation insurance for the trip.

If the risk is great, advise the traveler to consider another travel destination or to avoid areas of high exposure.
