Other air pollutants, such as acrolein, benzene, and formaldehyde, are present in smoke, but in much lower concentrations than particulate matter and carbon monoxide.

Health effects of smoke

The effects of smoke range from eye and respiratory tract irritation to more serious disorders, including reduced lung function, bronchitis, exacerbation of asthma, and premature death. Studies have found that fine particles are linked (alone or with other pollutants) with increased mortality and aggravation of pre-existing respiratory and cardiovascular disease. In addition, particles are respiratory irritants, and exposures to high concentrations of particulate matter can cause persistent cough, phlegm, wheezing and difficulty breathing. Particles can also affect healthy people, causing respiratory symptoms, transient reductions in lung function, and pulmonary inflammation. Particulate matter can also affect the body's immune system and make it more difficult to remove inhaled foreign materials from the lung, such as pollen and bacteria. The principal public health threat from short-term exposures to smoke is considered to come from exposure to particulate matter.



Carbon monoxide (CO) enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and tissues. The CO concentrations typical of population exposures related to wildfire smoke do not pose a significant hazard, except to some sensitive individuals and to firefighters very close to the fire line. Individuals who may experience health effects from lower levels of CO are those who have cardiovascular disease: they may experience chest pain and cardiac arrhythmias. At higher levels, as might be observed in a major structural fire, carbon monoxide exposure can cause headaches, dizziness, visual impairment,

reduced work capacity, and reduced manual dexterity, even in otherwise healthy individuals. At even higher concentrations (seldom associated solely with a wildfire), carbon monoxide can be deadly.

Wildfire smoke also contains significant quantities of respiratory irritants. Formaldehyde and acrolein are two of the principal irritant chemicals that add to the cumulative irritant properties of smoke, even though the concentrations of these chemicals individually may be below levels of public health concern.

One concern that may be raised by members of the general public is whether they run an increased risk of cancer or other long-term health impacts of exposure to wildfire smoke. People exposed to toxic air pollutants at sufficient concentrations and durations may have slightly increased risks of cancer or of experiencing other chronic health problems. However, in general, the long-term risk from short-term smoke exposure is quite low. Epidemiological studies have shown that urban firefighters exposed to smoke over an entire working lifetime have about a three-fold increased risk of developing lung cancer (Hansen 1990). This provides some

perspective on the potential risks. The major carcinogenic components of smoke are polycyclic aromatic hydrocarbons (PAHs). Although the carcinogens benzene and formaldehyde are also present in smoke, they are thought to present a lesser risk.

Not everyone who is exposed to thick smoke will have health problems. The level and duration of exposure, age, individual susceptibility, including the presence or absence of pre-existing lung or heart disease, and other factors play significant roles in determining whether or not someone will experience smoke-related health problems.

Sensitive populations

Most healthy adults and children will recover quickly from smoke exposures and will not suffer long-term consequences. However, certain sensitive populations may experience more severe short-term and chronic symptoms from smoke exposure. Much of the information about how particulate matter affects these groups has come from studies involving airborne particles in cities, though a few studies examining the effects of exposure to smoke suggest that the health effects of wildfire smoke are likely to be similar. More research is needed to determine whether particles from wildfires affect susceptible subpopulations differently.

Individuals with asthma and other respiratory diseases: Levels of pollutants that may not affect healthy people may cause breathing difficulties for people with asthma or other chronic lung diseases. Asthma, derived from the Greek word for panting, is a condition characterized by chronic inflammation of the airways, with intermittent bronchoconstriction and airflow obstruction, causing shortness of breath, wheezing, chest tightness, coughing, sometimes accompanied by excess phlegm production. During an asthma attack, the muscles tighten around the airways and the lining of the airways becomes inflamed and swollen, constricting the free flow of air. Because children's airways are narrower than those of adults, irritation that would create minor problems for an adult may result in significant obstruction in the airways of a young child. However, the highest mortality rates from asthma occur among older adults.

Individuals with chronic obstructive pulmonary disease (COPD), which is generally considered to encompass emphysema and chronic bronchitis, may also experience a worsening of their conditions because of exposure to wildfire smoke. Patients with COPD often have an asthmatic component to their condition, which may result in their experiencing asthma-like symptoms. However, because their pulmonary reserve has typically been seriously compromised, additional bronchoconstriction in individuals with COPD may result in symptoms requiring medical attention. Epidemiological studies have indicated that individuals with COPD run an increased risk of requiring emergency medical care after exposure to particulate matter or forest fire smoke. Exposure to smoke may also depress the lung's ability to fight infection. People with COPD may develop lower respiratory infections after exposure to wildfire smoke, which may require urgent medical care as well. In addition, because COPD is usually the result of many years of smoking, individuals with this condition may also have heart disease, and are potentially at risk from both conditions.

Individuals with airway hyperresponsiveness: A significant fraction of the population may have airway hyperresponsiveness, an exaggerated tendency of the bronchi and bronchioles to constrict in response to respiratory irritants and other stimuli. While airway hyperresponsiveness is considered a hallmark of asthma, this tendency may also be found in many nonasthmatics, as well; for example, during and following a lower respiratory tract infection. In such individuals, smoke exposure may cause bronchospasm and asthma-like symptoms.

Individuals with cardiovascular disease: Diseases of the circulatory system include, among others, high blood pressure, cardiovascular diseases, such as coronary artery disease and congestive heart failure, and cerebrovascular conditions, such as atherosclerosis of the arteries bringing blood to the brain. These chronic conditions can render individuals susceptible to attacks of angina pectoris, heart attacks, sudden death due to a cardiac arrhythmia, acute congestive heart failure, or stroke. Cardiovascular diseases represent the leading cause of death in the United States, responsible for about 30 to 40 percent of all deaths each year. The vast majority of these deaths are in people over the age of 65. Studies have linked urban particulate matter to increased risks of heart attacks, cardiac arrhythmias, and other adverse effects in those with cardiovascular disease. People with chronic lung or heart disease may experience one or more of the following symptoms: shortness of breath, chest tightness, pain in the chest, neck, shoulder or arm, palpitations, or unusual fatigue or lightheadedness. Chemical messengers released into the blood because of particle-related lung inflammation may increase the risk of blood clot formation, angina episodes, heart attacks and strokes.

The elderly. In several studies researchers have estimated that tens of thousands of elderly people die prematurely each year from exposure to particulate air pollution, probably because the elderly are more likely to have pre-existing lung and heart diseases, and therefore are more susceptible to particle-associated effects. The elderly may also be more affected than younger people because important respiratory defense mechanisms may decline with age. Particulate air pollution can compromise the function of alveolar macrophages, cells involved in immune defenses in the lungs, potentially increasing susceptibility to bacterial or viral respiratory infections.

Children. Children, even those without any pre-existing illness or chronic conditions, are considered a sensitive population because their lungs are still developing, making them more susceptible to air pollution than healthy adults. Several factors lead to increased exposure in children compared with adults: they tend to spend more time outside; they engage in more vigorous activity, and they inhale more air (and therefore more particles) per pound of body weight. Studies have shown that particulate pollution is associated with increased respiratory symptoms and decreased lung function in children, including symptoms such as episodes of coughing and difficulty breathing. These can result in school absences and limitations of normal childhood activities.

Pregnant women. While there have not been studies of the effects of exposure to wildfire smoke on pregnancy outcomes, there is substantial evidence of adverse effects of repeated exposures to cigarette smoke, including both active and passive smoking. Wildfire smoke contains many of the same compounds as cigarette smoke. In addition, recent data suggest that exposures to ambient air pollution in cities may result in low birthweight and possibly other,

more serious adverse reproductive effects. Therefore, it would be prudent to consider pregnant women as a potentially susceptible population as well.

Smokers. People who smoke, especially those who have smoked for many years, have already compromised their lung function. However, due to adaptation of their lungs to ongoing irritation, smokers are less likely to report symptoms from exposure to irritant chemicals than are nonsmokers. However, they may still be injured by wildfire smoke. Therefore, some smokers may unwittingly put themselves at greater risk of potentially harmful wildfire smoke exposures, believing that they are not being affected.

Recommendations for the public

Pre-season public service announcements

In areas where fires are likely to occur, state and local public health agencies should consider running pre-season public service announcements (PSAs) or news releases to advise the public on how to prepare for the fire season. PSAs should be simple (e.g., the season for wildfires is approaching; there are things you can do now to help protect your health and prepare your home in the event of a wildfire), and should list a contact phone number or website for further information.

News releases should be used to provide more detailed information, including information for the general public and for people with chronic diseases.

General recommendations to the public should include at least the following:

- 1. Have a several-day supply of nonperishable groceries that do not require cooking, since cooking can add to indoor pollutant levels.
- 2. If you develop symptoms suggestive of lung or heart problems, consult a health-care provider as soon as possible.
- 3. Be alert to PSAs.
- 4. Be aware that outdoor events, such as athletic games or competitions, may be postponed or cancelled if smoke levels become elevated.

Recommendations for people with chronic diseases should include at least the following:

- 1. Have an adequate supply of medication (more than 5 days)
- 2. People with asthma should have a written asthma management plan.
- 3. Contact a health-care provider if your condition worsens when you are exposed to smoke.
- 4. A news release could also include recommendations for preparing residences to keep smoke levels lower indoors, and on the appropriate use of facemasks. A sample news release developed by the Washington State Department of Health can be found in Appendix B.