Indoor Air Quality

Definition: Indoor air quality refers to the presence or absence of air pollutants in buildings. There are many sources of indoor air pollutants such as tobacco smoke, carbon monoxide (CO), and radon. Indoor air pollution can be caused by conditions that promote poor indoor air quality such as inadequate ventilation or excessive moisture that can lead to mold growth. These are indicators of potential health effects. CO poisonings and deaths are health outcome indicators.

Summary

Indoor air quality can have profound effects on our health and well-being because we spend so much time indoors. The quality of indoor air is affected by air pollutants as well as the ways buildings and homes are built and ventilated. Some sources of indoor air pollutants, such as tobacco smoking in public buildings, are regulated. But only industrial standards regulate levels of indoor air pollutants allowed in some commercial buildings and schools. There are no enforceable indoor air quality standards for homes. Education about sources of indoor air pollution and their control allows individuals, building managers, and institutions to reduce levels of indoor air contaminants.

Introduction

Washingtonians spend up to 90% of their time indoors.[1] As a result, exposure to particulate, chemical, or biological indoor air pollutants can have a greater impact on health than exposure to outdoor air pollutants. Levels of fine particles, carbon monoxide, nitrogen and sulfur oxides, volatile organic compounds (VOCs), radon, and biological contaminants such as certain molds and dust mites are often higher indoors than outdoors.

Exposure to fine particles formed from burning wood and gas can affect the lungs and heart. Fine particles from outdoor air pollution can travel indoors. Smoking tobacco indoors is a major source of combustion particles and irritant gases. Gas cooktops and ovens and room-vented gas or kerosene heaters are sources of combustion gases, particularly carbon monoxide, nitrogen oxides, excess moisture, and sulfur oxides. Negative pressure that results from the use of exhaust fans and clothes dryers in tightly built homes can pull combustion gases down flues into the living space, a phenomenon known as “backdrafting.”

Exposure to carbon monoxide reduces the ability of blood to carry oxygen to body tissues and organs such as the heart. Nitrogen dioxide is a respiratory irritant and can lower resistance to respiratory infections. Sulfur dioxide is an upper airway irritant that, in combination with fine particles, irritates the lungs.

VOCs such as solvents and formaldehyde irritate the eyes and the respiratory tract and can affect the nervous system. Indoor sources of VOCs include paint, cleaning and polishing products, plastics, and composite wood products used in building and furniture construction. VOCs can also be emitted from copy machines and laminators.

Young children, older adults, and people with cardiovascular disease (heart disease and stroke) and lung disease (including asthma) are more sensitive to indoor air contaminants. Indoor allergens that trigger asthma attacks include house dust mites, molds and other microorganisms, pets, and cockroaches.[2] Mold growth in buildings results from moisture intrusion (e.g., a leaking roof or plumbing problems) and condensation due to ventilation that is inadequate to remove excess indoor moisture generated by activities such as cooking and showering.

Methods to reduce indoor air pollutants include providing adequate ventilation and cleaning, eliminating indoor tobacco smoking, properly venting combustion appliances such as furnaces, routinely maintaining combustion appliances, controlling moisture, and thorough cleaning using low VOC-emitting cleaners, paints, and building materials.

Description of Potential Indicators

Limited information is available about the levels of indoor air contaminants in Washington homes,

businesses, and other buildings and the extent to which people are exposed.

Hazard indicators. The products and practices that cause indoor air pollution are widely known. But little information exists on the number of homes and other buildings with unhealthy levels of indoor air contaminants. The proportion of homes with water damage can be used as an indicator of the potential for mold growth.

Exposure indicators. The proportion of people who report being in contact with secondhand smoke is an exposure indicator.

Homes and other buildings can be tested for indoor air contaminants. This would be a source of exposure indicator information. This information is not systematically collected, however. Visible mold growth and moldy or musty smell can indicate potential exposure to mold.

Protective indicators. The number of schools using indoor air quality best management practices could be used as a protective indicator. Other protective indicators may include the level of public awareness about indoor air quality issues, the proportion of homes that are inspected or tested for radon and other indoor air contaminants, or the use of carbon monoxide detectors.

Health outcome indicators. Information about carbon monoxide death and non-fatal poisoning is available from death certificate and hospital discharge data. Cases of asthma are not reported to public health agencies. Although some information is available about the prevalence of asthma in the state from asking people about their asthma in surveys, indoor air pollutants are not the only cause of asthma.

Secondhand Smoke

Secondhand smoke (SHS), also called environmental tobacco smoke, is smoke released from burning tobacco products such as cigarettes, cigars, and pipes. Exposure of nonsmokers to SHS is sometimes called passive or involuntary smoking.

Maternal exposure to SHS during pregnancy has been linked to low birth weight. During infancy, exposure to SHS may contribute to sudden infant death syndrome. Children exposed to SHS have more respiratory problems (including acute respiratory illness and asthma) and middle ear infections. Adults exposed to SHS have higher rates of lung cancer, heart disease, and nasal sinus cancer. Evidence also suggests causal links between SHS exposure and spontaneous abortion, adverse effects on cognitive development and behavior among children, decreased lung function in children and adults, and cervical cancer.[3,4]

Among all Washington adults, 10% (±1%) had allowed smoking in their homes during the past month, according to the 2005 Washington Behavioral Risk Factor Surveillance System (BRFSS). Among current smokers only, 39% (±4%) had allowed smoking in their homes during the past month. In homes with a current smoker, the level of smoking inside was about half if there were children living in the home (BRFSS data).

The 2004 Healthy Youth Survey found that, in the prior week, 48% (±3%) of 10th-graders had been in a room with someone who was smoking, and 35% (±3%) had ridden in a car with someone who was smoking.

Several statewide policies exist in Washington to protect the public from SHS exposure. State law (RCW 70.160, 2005) prohibits smoking in public places and all places of employment. The Governor's Executive Order for State Offices (EO 88-06, 1988) bans smoking in state offices and vehicles. The Environmental Tobacco Smoke in Office Work Environments regulations (WAC 296-800-240, and WAC 296-307-590, 2006) prohibit smoking in office work environments.

Year 2010 Goals

Healthy People 2010 objectives seek to reduce the proportion of children who are regularly exposed to tobacco smoke in the home to 10%. In Washington in 2004, 18% of 6th-graders reported being in a room with secondhand smoke three or more days per week. This goal was measured differently in Washington than in *Healthy People 2010*, so the Washington rate is not comparable to the national goal. One *Healthy People 2010* objective is to reduce the proportion of nonsmokers exposed to environmental tobacco smoke to 45%. There are no similar secondhand smoke measures in Washington for comparison to this national goal.

Radon Testing

Radon is a radioactive gas that forms from the natural breakdown of uranium in soil and rock. In areas where the underlying rock contains uranium, radon can enter houses through cracks and openings in the building foundation or slab. Radon

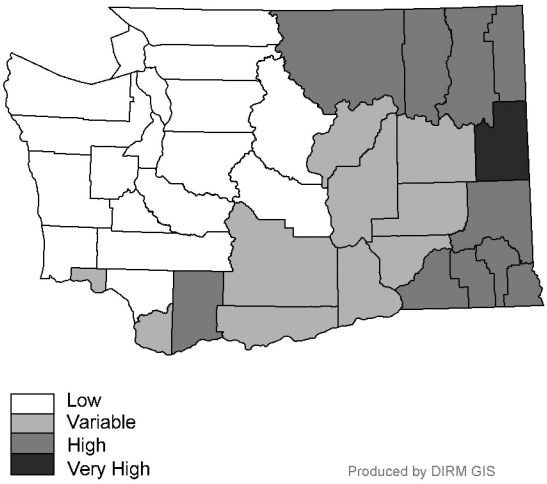
levels tend to be higher in basements and on the ground floor.

Radon exposure is known to cause lung cancer, particularly in people who smoke.[5] Because radon gas is invisible and odorless, the only way to know the radon level in a building is to test for it. Eight percent of Washington adults said they tested their homes for radon in the 1997 BRFSS (the most recent data available).

Geographic Variation

The counties with high or very high radon potential because of their geology are Okanogan, Ferry, Stevens, Pend Oreille, Whitman, Walla Walla, Columbia, Garfield, Asotin, Skamania, and Spokane (see map below).[6] People living in these counties reported the same level of home testing for radon as the rest of the state. High radon levels can occur in areas of low radon potential.

RADON POTENTIAL BY COUNTY



To control radon in new construction in those counties known to have high or very high radon potential, the Washington State Building Code (see Technical Notes) requires underslab venting, which reduces the infiltration of radon gas into buildings.

Year 2010 Goals

Healthy People 2010 aims to increase the proportion of people who live in homes tested for radon to 20%; the 1998 national baseline was 17%. Both are higher than the 8% of Washington residents who reported home radon testing 1997.

Carbon Monoxide Poisoning

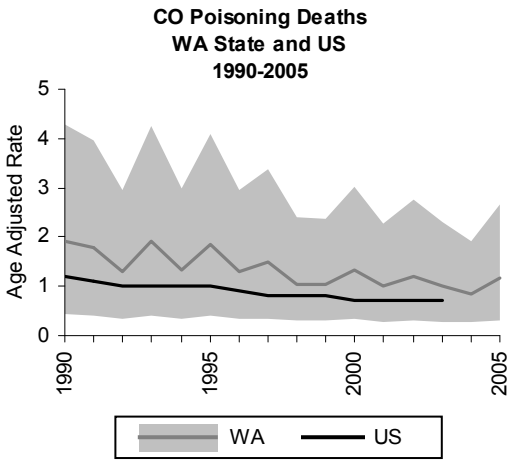
Carbon monoxide (CO) is a colorless, odorless gas produced through incomplete combustion. Indoor sources of CO include fuel-burning appliances such as wood stoves, gas ranges, gas hot water heaters, gas and oil heaters, furnaces, room-vented gas heaters and fireplaces, and kerosene space heaters. Cigarette smoke is also a source of CO. CO can enter the home from cars left running in attached garages. CO can also enter buildings from vehicles idling near fresh air intake vents. Gasoline and diesel-powered generators are a source of CO when operated inside or near homes. During power outages (such as following the 2006 windstorm), operation of generators and charcoal cook-stoves inside homes can be a source of fatal levels of CO. Energy-efficient “tight” homes exacerbate the problem by reducing unintentional ventilation rates from cracks and gaps in the building.

Exposure to even low levels of CO can produce headache, dizziness, decreased hand-eye coordination, decreased stamina, weakness, confusion, disorientation, tiredness, chest pain (in people with existing heart disease), nausea, and vision problems. Higher or prolonged exposure can cause unconsciousness and death. CO is linked to a variety of other health problems such as cardiovascular disease, neuropsychological impairment, and adverse birth outcomes.[7,8]

Routine inspection and maintenance of furnaces and other fuel-burning appliances decreases the likelihood of CO air contamination. Indoor CO levels can also be reduced or eliminated by providing adequate ventilation when using fuel-burning appliances. CO monitors alert occupants when CO levels are higher than normal. Newly arrived immigrants with limited English proficiency were at increased risk for CO poisoning from using CO-emitting heat sources inside homes during power outages following the 2006 windstorm. Community-based interventions such as targeted distribution of linguistically appropriate educational materials and CO detectors during power outages might be effective at preventing poisonings in these populations.

Time Trends

In the 16-year period 1990–2005, 1,197 Washington residents died from acute exposure to CO, an



average of about 75 deaths per year. This is equivalent to an age-adjusted mortality rate of approximately 1 per 100,000. The death rate has declined by about 50% over the past two decades, probably due to reductions in automotive engine emissions.

During the years 1990–2005, there were about 53 hospitalizations per year in Washington State for symptoms related to CO poisoning. In 2004, there were an estimated 3,274 hospitalizations from CO poisoning across the country. It is common for poisoning episodes to involve multiple victims living or working in an affected building.

Year 2010 Goals

Healthy People 2010 seeks to increase or maintain the number of territories, tribes, and states that monitor diseases or conditions that can be caused by exposure to environmental hazards. Carbon monoxide poisoning is listed as a condition under this objective. CO poisonings are not systematically monitored in Washington.

Indoor Mold

Flooding, water leaks, condensation, high relative humidity, inadequate ventilation, and poor drainage around buildings can result in mold growth inside buildings. Mold can start growing within 24–48 hours of a flood or other water intrusion event. Prompt cleanup and removal or rapid drying of wet materials is critical to prevent mold growth. Visible mold growth or a moldy or musty smell can indicate a moisture problem within a building.

Inhaling or touching mold can cause allergic reactions to the respiratory tract or skin. Exposure to mold indoors is associated with upper respiratory symptoms, coughing, wheezing, asthma symptoms in people with asthma, lung infections, and hypersensitivity pneumonitis in susceptible people.[9] Some molds can also produce toxins (called mycotoxins) under certain conditions in defense against other molds and bacteria. Research continues into the possible human toxicity of mycotoxins from indoor exposures.

The 2004 Washington BRFSS asked questions about water damage, the presence of a moldy or musty smell, and visible mold in the home. Among all Washington adults, 23% (±1%) reported having water damage in their home in the past five years. Fourteen percent reported having a moldy or musty smell in their home during the past 12 months. Fourteen percent saw mold or mildew covering an area at least the size of a dollar bill in their home during the past 12 months. Adults who also reported having asthma were 60% more likely to have noticed a moldy or musty smell or to have seen mold in their home compared to non-asthmatics.

There are no statewide regulations that address mold growth or mold cleanup in buildings. A 2005 law (RCW 59.18.060) requires landlords to notify tenants about the health hazards from exposure to indoor mold and steps to control mold growth in their dwellings. The Washington State Department of Health provides information and recommendations for preventing mold growth in homes and other types of buildings. In particular, it focuses its educational efforts on those who manage schools and other public buildings.

Year 2010 Goals

There are no *Healthy People 2010* objectives that pertain specifically to indoor mold.

Indoor Air Quality in Schools

In 2005, more than a million school children in Washington State attended 2,216 public schools and 450 private schools.[10] Good indoor air quality in these environments is essential for promoting learning and maintaining student health. Children perform poorly in classes with poor indoor air quality.[11] In Washington, poor indoor air quality in schools has resulted in student and staff health concerns evident in reports of headaches, rashes, fatigue, eye or respiratory tract irritation, increases in asthma or asthma attacks, and increases in the number of colds and other infectious illnesses. The 2004 Healthy Youth Survey found that about 14% of 6th-graders in Washington had asthma. These students may be particularly susceptible to poor indoor air quality in schools.

Factors that contribute to poor indoor air quality in schools include poor design and construction, lack of or poor maintenance, and a lack of indoor air quality plans and oversight. In some cases, water intrusion problems have resulted in mold infestation. Other indoor air quality problems reported for schools include inadequate ventilation, the presence of chemical or biological contaminants, over- or under-heating, and low or excessive humidity.

There are no statewide regulations or programs that govern or monitor indoor air quality in schools other than regulations governing the level of fresh air ventilation. Individual schools and school districts address indoor air quality issues as part of their general facility maintenance. School personnel typically report indoor air quality problems to their district facilities manager and to public health agencies. The Department of Health provides technical assistance and works with the state Office of Superintendent of Public Instruction to address air quality issues. The Department provides training to schools, local health jurisdictions, and the public on indoor air quality in schools.

The U.S. Environmental Protection Agency (EPA) developed the Tools for Schools program to help schools evaluate and promote good indoor air quality. The program includes a kit, provided free to schools, with information on how to implement good indoor air quality practices. In Washington State, 519 schools (19% of the total number of schools) have received the kits from EPA.

Year 2010 Goals

Healthy People 2010 aims to increase the proportion of the nation's primary and secondary schools that have official school policies protecting students and staff from environmental hazards such as poor indoor air quality.

Intervention Strategies

Education about sources of indoor air pollution is important to help people identify and solve indoor air quality problems. Ways to reduce indoor air contaminant exposures include the use of low-emitting building materials and proper ventilation of combustion appliances. Residential indoor air testing for radon can identify unhealthy levels of this gas. CO detectors used in homes can warn occupants of dangerous CO levels. Monitoring indoor levels of carbon dioxide (CO_2) and relative humidity in schools can help identify ventilation problems. Laws that prohibit smoking in all public buildings have reduced people's exposures to environmental tobacco smoke. Washington's 2005 Green Building Legislation requires all new state-funded facilities larger than 5,000 square feet to meet green building criteria; such laws will improve indoor air quality by requiring the use of healthier building materials.

See Related Chapters: Children's Environmental Health, Asthma, Tobacco Use, and Outdoor (Ambient) Air Quality.

Data Sources (For additional detail, see Appendix B.)

ETS data: 2005 Behavioral Risk Factor Surveillance System (BRFSS) and 2004 Washington State Healthy Youth Survey (HYS).

CO deaths: Washington State Death Certificate data

CO hospitalizations: Washington State Hospitalization data

Mold in home data: 2004 BRFSS

Home radon testing data: 1990, 1993, and 1997 BRFSS

Radon potential data: Washington State Department of Health, Office of Radiation Protection, 1994.

Number of schools requesting Tools for Schools kits from EPA: EPA Region 10, Indoor Air Quality Program, as of July 31, 2006.

Asthma prevalence among 6th-graders: 2004 Healthy Youth Survey.

For More Information

Department of Health Tobacco Prevention and Control Program, Information on Secondhand Smoke (http://www.doh.wa.gov/Tobacco/secondhand/secondhand.htm)

Department of Health Indoor Air Quality Program (http://www.doh.wa.gov/ehp/ts/IAQ/default.HTM)

Department of Health Carbon Monoxide Poisoning Fact Sheet (http://www.doh.wa.gov/ehp/ts/IAQ/CO_Fact_Sheet.htm)

U.S. Centers for Disease Control and Prevention Carbon Monoxide Poisoning Info (http://www.cdc.gov/co/default.htm)

U.S. Environmental Protection Agency (EPA) indoor air quality "Tools for Schools" website (http://www.epa.gov/iaq/schools/tools4s2.html)

School Indoor Air Quality Best Management Practices, Department of Health, 2003. (www.doh.wa.gov/ehp/ts/iaq/schooliaqbmp.pdf)

Washington State Department of Health and Office of Superintendent of Public Instruction, 2005. Responding to Indoor Air Quality Concerns in Schools, A protocol to assist schools in addressing air quality concerns.

Washington's Green Building Legislation, Chapter 39.35D RCW

Technical Notes

WAC Chapter 51-13 The Washington State Ventilation and Indoor Air Quality Code provides minimum standards for the design and installation of mechanical ventilation systems as well as radon-resistive construction standards for mitigation systems in new construction.

Outdoor background levels of radon vary but average 0.4 pCi/L. Indoor levels vary widely from background to hundreds of pCi/L. The EPA Action Level for radon is 4 pCi/L.

Due to changes in ICD coding, the yearly numbers for CO deaths from 1979–1998 are not comparable to the period after 1998.

The state ventilation and indoor air quality code (WAC 51-13) requires fresh replacement air to provide dilution ventilation in schools (15 cubic feet/minute/person in classrooms, 20 in offices and labs).

Endnotes

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[7] Raub, J. A., Mathieu-Nolf, M., Hampson, N. B., & Thom, S. R. (2000, April 7). Carbon monoxide poisoning--a public health perspective. *Toxicology*, *145*(1), 1-14.

[8] Salam, M. T., Millstein, J., Li, Y-F., Lurmann, F. W., Margolis, H. G., & Gilliland, F. D. (2005, November). Birth outcomes and prenatal exposure to ozone, carbon monoxide, and particulate matter: results from the Children's Health Study. *Environmental Health Perspectives, 113*(11), 1638-1644.

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