



Indoor air pollution and effects on human health

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Abstract

Background and Purpose: Indoor pollutants could be significant public health risks. People in modern societies spend about 90% of their time in indoor environment. In spite of the evidence of harm to human health, poor indoor environments are generally hard to understand.

Materials and Methods: There are numerous indoor atmospheric pollutants. Specifically, combustion sources, building materials, volatile organic compounds, central heating and cooling system are described.

Results: Indoor home environments are the site of a variety of biological and other environmental hazards. Indoor environmental quality has a significant impact on public health and well-being. These hazards cause and exacerbate a variety of adverse health effects in humans, ranging from acute and chronic respiratory symptoms and diseases to cancer. We review the effects of indoor allergen exposure and sensitization on asthma, focusing on dust mite, fungi, indoor pollutants such as ozone, particulate matter nitrogen dioxide, environmental tobacco smoke, sulfur dioxide, carbon monoxide and dampness of buildings. Additionally, the effects of lead, as well as carcinogenic effects of asbestos, radon, and smoking habits are described.

Conclusions: Preventive measures, such as identification of a source of chemical, physical, or biological pollutants that may have deleterious health effects, and improvement of such harmful environmental conditions should be undertaken.

INTRODUCTION

As early as several centuries ago B.C. the famous Greek »father of medicine« Hippocrates (460-370 B.C.) was aware of the adverse effects of polluted air and the damage of living in damp housing. Poor indoor environmental quality is an important health risk worldwide. People in modern societies spend about 90% in indoor environments, which has a significant impact on public health and well-being (1).

Numerous health risks have been identified in homes and are a public health priority (2). Hazards in indoor environments include biological and chemical contaminants as well as the effects of physical agents. Main sources of indoor pollution include combustion sources (oil, gas, kerosene, coal, wood and tobacco products), volatile organic compounds, building materials (asbestos), carpets, house cleaning and maintenance, personal care or hobbies, central heating and cooling system and humidification devices, lack of ventilation, too much humidity, water infiltration or leakage, carbon monoxide and other gases, radon and other noxious agents (3, 4).

TABLE 1

Some of the sources and potential health effects of indoor air pollutants.

Pollutant	Indoor Sources	Potential Health Effects
Environmental tobacco smoke, carbon monoxide, nitrogen oxides and other gases, organic chemical, pesticides, formaldehyde	Cigarette and cigar smoke, unventilated or malfunctioning gas appliances, wood stoves, tobacco smoke, cooking gases, gas heaters, formaldehyde, volatile organic compounds, odors, products for household cleaning and maintenance, combustion pollution, aerosol sprays, solvents, glues, cleaning agents, pesticides, paints, moth repellents, air fresheners, drycleaned clothing, treated water, products used to kill pests such as insecticides, termiticides and herbicides. Also lawn and garden products, pressed wood products such as plywood and particleboard; furnishings; wallpaper; durable press fabrics	Headache, fatigue, poor memory, cough, respiratory irritation, bronchitis, pneumonia in children, emphysema, lung cancer, heart disease, eye, nose and throat irritation, nausea, angina, impaired vision and mental functioning, fatal at high concentrations, wheezing, nasal congestion, skin irritation, dizziness, confusion, asthma, loss of coordination, damage to liver, kidney and brain; various types of cancer, damage to the central nervous system and liver, allergic reactions; cancer
Respirable particles, asbestos	Cigarettes, wood stoves, fireplaces, aerosol sprays, and house dust, textile, wallboard, wood, decorating hazards, insulation, damaged or deteriorating insulation, fireproofing, and acoustical materials	Eye, nose and throat irritation, increased susceptibility to respiratory infections and bronchitis, lung cancer, asbestosis, mesothelioma
Radon	Soil under buildings, some earth-derived construction materials, and groundwater	Lung cancer
Lead	Sanding or open-flame burning of lead paint; house dust	Nerve disorders, anemia; damage of kidney; growth retardation
Biological organisms and other organic pollutants	House dust, dust mites, pets, bedding; poorly maintained air conditioners, humidifiers and dehumidifiers, wet or moist structures, furnishings, insects, cockroach parts, pollen, animal dander and saliva, protein in animal urine, bacterial endotoxins and fungal materials	Coughing, shortness of breath, allergic rhinitis, asthma, eye, nose, and throat irritation, humidifier fever, influenza, other infectious diseases, myalgia, malaise, fatigue, hypersensitivity pneumonitis, digestive problems, itching

Chemical hazards include numerous chemical agents, such as nitrogen and sulfur oxides, ozone, pesticides, formaldehyde, infectious agents, and biological agents (microbial organisms, mold, dust mites) (5-8).

Temperature, relative humidity, extensive cold or hot surfaces, and draft effects also modify the effects of chemical and biological contaminants. Some agents include allergens, and agents such as colorless, odorless gases and aerosolized toxins, physical stimuli such as bright lights and loud sounds (9). Chaiear *et al.* recently (10) described persons suffering from erythema and other skin changes, conjunctive infection caused by indoor radiation pollution due to ultraviolet C radiation from germicidal ultraviolet lamps.

Table 1 presents some of the sources of indoor air pollutants and their potential health effects.

Identification or recognition of the deleterious effects of some agents are determined by evaluating the risk of developing certain diseases or impairment. It is very important to estimate the dose-effect relationship of a certain agent on individual bases. Larger doses of noxious agents may have detrimental effect on the whole body. Such effects depend on individual sensitivity to certain harmful agent/s. Simultaneous exposure to different environmental agents may have cumulative noxious effects. There are Maximal Allowable Concentrations (MAC) for almost all environmental agents (organic and physical)

to which subjects could be exposed without a risk for developing disease.

Deleterious health effects may show up after a single or repeated exposure to certain indoor pollution depending on age, preexisting medical conditions and individual sensitivity.

COMBUSTION PRODUCTS

Diverse indoor combustion sources contribute to the quality of indoor air environment (11). Indoor combustion products include mostly environmental tobacco smoke, woodsmoke, carbon monoxide, nitrogen and sulfur dioxide, soot and organics from incomplete combustion.

Combustion products – dangerous gases and particles can be generated by different appliances such as water heaters, unvented gas or kerosene space heaters, etc. Among such gases, the most frequent are carbon monoxide and nitrogen oxides.

VOLATILE, NONVOLATILE AND OTHER NONBIOLOGICAL AGENTS

These compounds include household and office products such as formaldehyde, pesticides, solvents, cleaning agents, heavy metals (airborne lead, mercury vapor, asbestos, radon).

Chemicals

The chemicals we breathe (such as perfumes, formaldehyde, pesticides, solvents, cleaning agents, benzene, perchloroethylene, hair sprays, household products (finishes, rug and oven cleaners, paints, thinners, dry cleaning fluids), some copiers and printers, glues and adhesives, markers and photo solutions are among some of the common products that may emit organic compounds. Volatile organic compounds are among major pollutants of indoor air which have a significant impact on indoor air quality and thus affect human health (12).

Multiple chemical sensitivity (MCS) is a syndrome in which multiple symptoms are caused by extremely low concentrations of environmental chemicals (13). Common symptoms include irritation of the eye, nose and throat, hoarseness of voice, headache, fatigue, difficulty in concentrating, depressed mood, memory loss, weakness, dizziness, heat intolerance and arthralgia (14). Symptoms are precipitated by a wide array of common environmental agents.

Asbestos

Indoor exposures to this agent are generally quite low, they may be higher than outdoor concentrations, and can be substantial following remodeling, pesticide application, or other product use. Asbestos exposure only exists if the asbestos-containing material is distributed and microscopic asbestos fibers are released into the air (15).

Breathed-in asbestos fibers in the lungs can increase the risk of lung cancer and mesothelioma. Smoking drastically increases the risk of lung cancer from asbestos exposure. Average indoor asbestos levels are extremely low so that the related health risk is assumed to be low from the mere presence of asbestos-containing material.

Lead

Everyone is exposed to trace amounts of lead through inhalation of lead vapors since many consumer products and paints contain lead.

Lead toxicity causes hematological, gastrointestinal and neurological dysfunction. Anemia is common and damage to the nervous system may cause impaired mental function. Other symptoms are appetite loss, abdominal pain, constipation, fatigue, sleeplessness, irritability and headache. Severe or prolonged exposure may also cause chronic nephropathy, hypertension and reproductive impairment (16). Lead inhibits some enzymes, alters cellular calcium metabolism, stimulates synthesis of binding proteins in kidney, brain and bone, and slows down nerve conduction.

Radon

Radon in air is ubiquitous. Radon gas, a naturally occurring radioactive soil gas, can infiltrate the air in the house. Radon enters homes through cracks in the foundation, floor drains, sump pumps and other openings (17).

When radon is inhaled, its radioactive breakdown products deliver a radioactive assault to the lungs, which increases the risk of lung cancer. For smokers, the risk of lung cancer is significant due to the synergistic effects of radon and smoking. However, radon may also be the leading cause of lung cancer among nonsmokers. Radon is responsible for about 21,000 lung cancer deaths every year (18).

BIOLOGICAL ORGANISMS AND OTHER ORGANIC POLLUTANTS

Biological organisms include bacteria, molds, fungi, mildew, pollen, dust mites and other insects, arthropod parts, animal dander (tiny scales from hair, feathers or skin), animal saliva, infectious agents (bacteria and viruses), mycotoxins and pollen.

Increased exposure to indoor allergens and selected outdoor allergens such as grass pollen and molds, particularly house-dust, cockroaches, animal allergens as well as smoking are important risk for developing of respiratory diseases, particularly asthma and allergic sensitization (19).

Bacteria, fungi and molds can flourish in improperly maintained air ducts, air conditioners, humidifiers, dehumidifiers, air-cleaning filters, carpets and in improperly ventilated places where moisture is likely to collect, such as bathrooms, kitchens, laundry rooms and basements.

Adverse health effect associated with certain fungi is small molecular toxin (mycotoxin) produced by these fungi. The most frequent disease related to biological factors include legionaire's disease, allergic reactions, hypersensitivity pneumonitis, humidifier fever and tuberculosis.

Molds

Molds are the major pollutant in the indoor environment. About 5% of individuals are predicted to have some allergic airway symptoms from molds over life time. Indoor mold can usually be seen or smelled. Mold can be found behind painted walls, carpets, cabinets, walls, ceilings, and even in cleanly-maintained kitchen material and furnishings which provide ample nutrition for many species of molds.

Health problems that arise from exposure to mold include allergic illness, irritant effects, infection and toxic effects. For people that are sensitive to molds, symptoms such as nasal and sinus irritation or congestion, dry hacking cough, wheezing, skin rashes or burning, watery or reddened eyes may occur (20). Mold can also trigger asthma attacks in persons with asthma. Superficial fungal infections of skin and nails are relatively common in normal individuals. Headaches, memory problems, nosebleeds and body aches and pains are sometimes reported in mold complaints.

Air conditioning system

In air-conditioned buildings indoor air quality is dependent on the efficiency of air-conditioning and humidifier systems since these systems provide a suitable environment for the proliferation of microorganisms. Bioaerosols may spread in the indoor environment through the air-conditioning system.

Humidifier fever/hypersensitivity pneumonitis is a disease with symptoms of hypersensitivity pneumonitis related to bacterial endotoxins, fungi and amebae found in humidifier reservoirs, air conditioners and aquaria. Disease is characterized by fever, headache, chills, myalgia and malaise. It normally subsides within 24 hours without residual effects.

Humidifier lung disease with cough fever, myalgia and arthralgia was described as a result of inhaling endotoxin present in the humidifier water (21). Hypersensitivity pneumonitis due to use of portable home ultrasonic humidifier was described by Alvarez-Fernandez *et al.* (22) and Volpe *et al.* (23).

PREVENTION

The US Environmental Protection Agency (EPA) rates indoor pollution among the top environmental health risks. For this reason, it is important to assess the air quality of workplaces and homes. The indoor air levels of many pollutants may be 2-10 times higher than outdoor levels. These levels of indoor air pollutants are of particular concern because most people spend as much as 90% of their time indoor.

Preventive measures should be directed toward identifying indoor air sources that may be possible causes and reduce exposure to biological contaminants with immediate health benefits. The measures to keep healthy indoor air we breathe include: introduction and distribution of adequate ventilation air; control of airborne contaminants; maintenance of acceptable temperature and relative humidity. This also includes a special attention to moisture control.

Many types of adjustments could improve environmental conditions. For instance, open windows improve air flow, minimizing the temperature decreases the growth of molds, and restricted use of colognes or perfumed soaps, shampoos, deodorants, and air fresheners can help control the indoor environment.

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