

trigger for asthma and allergies. Cockroach allergens appear to be excessive in 30–50 percent of inner-city housing and affect 5–15 percent of the population, whereas dust mites appear to be the dominant allergen in other environments.

Interventions known to have beneficial effects include the installation of impervious mattress and pillow covers, which can reduce allergen exposure by 90 percent. Other dust mite control measures include dehumidification, laundering bedding, and removal of carpets and other dust sinks. Cleaning carpets with tannic acid solution has also been demonstrated to greatly reduce dust mites. Asthma prevention program costs have been estimated at about \$500 per unit, which includes about \$150 for educational interventions. Additional information is available in HUD's research topic paper, "Healthy Homes Issues: Asthma" available at the Resources, Technical Resources link of HUD's Healthy Homes Initiative Web site, linked to HUD's Web site, <http://www.hud.gov>.

Asbestos: Asbestos is a mineral fiber that has been used commonly in a variety of building construction materials and household products for insulation and as a fire-retardant. The Environmental Protection Agency (EPA) and the Consumer Product Safety Commission (CPSC) have banned most asbestos products. Manufacturers have also voluntarily limited uses of asbestos. Today, asbestos is most commonly found in older homes, in pipe and furnace insulation materials, asbestos shingles, millboard, textured paints and other coating materials, and floor tiles. Elevated concentrations of airborne asbestos can occur when asbestos-containing materials (ACMs) are disturbed by cutting, sanding or other remodeling activities. Improper attempts to remove these materials can release asbestos fibers into the air in homes, increasing asbestos levels and endangering the people living in those homes. The most dangerous asbestos fibers are too small to be visible. After they are inhaled, they can remain and accumulate in the lungs. Asbestos can cause lung cancer, mesothelioma (a cancer of the chest and abdominal linings), and asbestosis (irreversible lung scarring that can be fatal). Most people with an asbestos-related disease were exposed to elevated concentrations on the job; some developed disease from exposure to clothing and equipment brought home from job sites. As with radon, dose-response extrapolations suggest that lower level exposures, as may occur when asbestos-containing building materials deteriorate or are disturbed, may also cause cancer.

Intact asbestos-containing materials are not a hazard; they should be monitored for damage or deterioration and isolated if possible. Repair of damaged or deteriorating ACMs usually involves either sealing (encapsulation) or covering (enclosure) it. Repair is usually cheaper than removal, but it may make later removal of asbestos more difficult and costly. Repairs should be done only by a professional who is trained and certified to handle asbestos safely. Repairs can cost from a few hundred to a few thousand dollars and removal can be more expensive.

Combustion products of heating and cooking appliances: Burning of oil, natural gas, kerosene, and wood for heating or cooking purposes can release a variety of combustion products of health concern. Depending upon the fuel, these may include carbon monoxide (a chemical asphyxiant), oxides of nitrogen (respiratory irritants), polycyclic aromatic hydrocarbons (e.g., the carcinogen benzo[a]pyrene), and airborne particulate matter (respiratory irritants). Carbon monoxide, an odorless gas, can be fatal. Nitrogen dioxide can damage the respiratory tract, and sulfur dioxide can irritate the eyes, nose and respiratory tract. Smoke and other particulates irritate the eyes, nose and throat, and can cause lung cancer.

Improper venting and poor maintenance of heating systems and cooking appliances can dramatically increase exposure to combustion products. Experts recommend having combustion heating systems inspected by a trained professional every year to identify blocked openings to flues and chimneys, cracked or disconnected flue pipes, dirty filters, rust or cracks in heat exchangers, soot or creosote build-up, and exhaust or gas odors. Installing a carbon monoxide detector is also recommended; however, such a detector will not detect other combustion by-products.

Insect and rodent pests: The observed association between exposure to cockroach antigen and asthma severity has already been noted above. In addition, cockroaches may act as vehicles to contaminate environmental surfaces with certain pathogenic organisms. Rodents can transmit a number of communicable diseases to humans, either through bites, arthropod vectors, or exposure to aerosolized excreta. In addition, humans can become sensitized to proteins in rodent urine, dander and saliva. Such sensitization may contribute to asthma severity among children. Insect and rodent infestation is frequently associated with substandard housing that makes it difficult to eliminate. Treatment of rodent and insect infestations often includes the use of toxic pesticides that may present hazards to occupants (see below). Integrated pest management (IPM) for rodents and cockroaches, which reduces the use of pesticides, is estimated to cost approximately \$150 per unit. IPM control measures include sealing holes and cracks, removing food sources and the use of traps. In technical terms, IPM is the coordinated use of pest and environmental information with available pest control methods to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment. (One information source is the University of Minnesota's electronic textbook of Integrated Pest Management, available at <http://ipmworld.umn.edu/textbook.htm>.)

Lead: Exposure to lead, especially from deteriorating lead-based paint, remains one of the most important and best-studied of the household environmental hazards to children. Although blood lead levels have fallen nationally, a large reservoir of lead remains in housing. The National Health and Nutrition Examination Survey (1991–1994)

showed that nearly one million U.S. preschoolers still have elevated blood lead levels. Overall, the prevalence rate among all children under six years of age is 4.4 percent. Among low-income children living in older housing where lead-based paint is most prevalent, the rate climbs to 16 percent; and for African-American children living in such housing, it reaches 21 percent.

The National Survey of Lead and Allergens in Housing (2000) estimates that 38 million dwellings have some lead-based paint, and that 24 million have significant lead-based paint hazards. Of those, about 4.8 million have young children and of those, about 1.2 million have household incomes under \$30,000 per year. Costs for Lead Hazard Control can range anywhere from \$500 to \$15,000 per unit. Corrective measures include paint stabilization, enclosure and removal of certain building components coated with lead paint, and cleanup and "clearance testing," which ensures the unit is safe for young children.

Mold and moisture: An analysis of several pulmonary disease studies estimates that 25 percent of airways disease, and 60 percent of interstitial lung disease may be associated with moisture in the home or work environment. Moisture is a precursor to the growth of mold and other biological agents, which is also associated with respiratory symptoms. An investigation of a cluster of pulmonary hemosiderosis (PH) cases in infants showed PH was associated with a history of recent water damage to homes and with levels of the mold *Stachybotrys atra* (SA) in air and in cultured surface samples. Associations between exposure to SA and "sick building" symptoms in adults have also been observed. Other related toxigenic fungi have been found in association with SA-associated illness and could play a role. For sensitive individuals, exposure to a wide variety of common molds may also aggravate asthma. Addressing mold problems in housing requires coordination among the medical, public health, microbiological, housing, and building science communities. Additional information is available in HUD's research topic paper, "Healthy Homes Issues: Mold" available at the Resources, Technical Resources link of HUD's Healthy Homes Initiative website, linked to HUD's Web site, <http://www.hud.gov>.

The cost of mold/moisture-related intervention work (e.g., IPM, clean and tune furnace, remove debris, vent clothes dryer, cover dirt floor with impermeable vapor barrier) is a few hundred dollars, unless major modification of the ventilation system is needed. For example, in Cleveland, mold interventions, including repairs to ventilation systems and basement flooring, in the most heavily contaminated homes range from \$500–\$5,000, with some costs also being dedicated to lead hazard control simultaneously through its Lead+Asthma program.

Pesticide residues: According to the EPA, 75 percent of U.S. households used at least one pesticide product indoors during the past year. Products used most often are insecticides and disinfectants. Another study suggests that 80 percent of most people's exposure to pesticides occurs indoors and