

Intervention Strategies

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- Keep it Safe
- Keep it Contaminant-Free
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Interventions include physical modifications to a home to make it healthier and safer. They also include educational efforts to change the knowledge and behavior of occupants so they can protect themselves from health and safety hazards.

A housing assessment (described in Chapter 4) helps inform the intervention strategy and prioritize selection of interventions. This chapter describes intervention strategies according to the Seven Principles of Healthy Homes, and reviews evidence supporting their effectiveness. Resident education is an intrinsic component of all seven principles and is discussed at the end of this chapter.

Health benefits from combined structural and behavioral interventions are greater than resident education alone. The HUD/CDC Healthy Homes Reference Manual provides detailed descriptions of construction and maintenance practices. Appendix 5.1 describes specific healthy housing interventions and details their relationship to “green” building design systems, such as the Enterprise Community Partners’ Green Community Standards and the LEED (Leadership in Energy and Environmental Design) rating system. The Appendix also contains technical information on EPA’s Indoor airPLUS Construction Specifications for new construction.

Intervention Principles

Prioritizing Interventions

Depending on the local program and available resources, priorities can be established in

Key Messages

- Healthy housing interventions make a home dry, ventilated, safe, contaminant-free, pest-free, clean, and maintained.
- Specific healthy homes interventions often have many benefits and should be implemented by both owners and occupants.
- Substantial evidence shows that healthy housing interventions are effective.
- Interventions require resident education to be effective.
- Interventions can prevent harm; they are more effective and less expensive than acting after harm has occurred.

This chapter is organized around the *Seven Principles of a Healthy Home*. Keep it:

- Dry
- Ventilated
- Pest-free
- Safe
- Contaminant-free
- Clean
- Maintained

several different ways (see Table 4.1 in the previous chapter). One general approach involves first correcting imminent hazards such as carbon monoxide or a sagging roof; second, correcting hazards associated with chronic health conditions such as asthma triggers; and third, taking steps to prevent other housing deterioration. While many jurisdictions have housing repair programs that address imminent hazards, chronic problems and preventative strategies also require attention. Further, there are likely to be some housing units that simply cannot be brought to a healthy status and need to be condemned, demolished, or vacated.

Similarly, some localities are slated for widespread demolition and development, making healthy homes investments in existing housing in the near term inappropriate. Healthy homes programs should always coordinate their efforts with local planning officials in order to maximize the impact and durability of the work. The case studies in Appendix 1.2 demonstrate how different programs have established intervention priorities.

Shared Responsibilities for Implementing Interventions

Owners, property managers, maintenance staff, and tenants share responsibility for a healthy and safe home environment in rental housing. Because home environments experience normal wear and tear and all systems (e.g., electrical, plumbing) degrade over time, maintenance is also an ongoing responsibility. Owners are responsible for providing a living environment that complies with housing and building codes, responding to tenant reports of needed repairs, and conducting periodic inspections (e.g., at unit turnover or annually). Tenants are responsible for maintaining the cleanliness of the property and for immediately reporting maintenance needs to the property owner.

Multiple Benefits of Interventions

Many healthy homes interventions result in multiple health benefits. For example, eliminating a moisture problem helps prevent mold, dust mites, deteriorated paint, structural rot and degradation, and pest infestation. Radon

mitigation not only reduces exposure to radon but is effective in reducing other soil gases and can reduce moisture levels.¹ Keeping food preparation areas clean and maintaining smooth and cleanable surfaces helps to eliminate pest infestation, prevents dust accumulation, and reduces infections and food-borne diseases. As part of a program's education efforts with owners and occupants, these varied intervention benefits should be presented and emphasized so that the outcomes are well understood.

Proper Use of Products

Some home-related injuries and health problems can be traced to improper use and storage of certain products. For example, combining incompatible cleaning agents such as ammonia-based cleaners and bleach can produce toxic gases. Misuse of pesticides can be associated with poisonings. Improper installation or location of warning devices such as smoke or carbon monoxide alarms can promote a false sense of security.

Saving Treatment Costs through Prevention

The health and societal costs of housing-related disease or injury far outweigh the costs of prevention. Savings associated with preventing childhood lead poisoning from residential lead exposures run well over \$67 billion.² The cost of controlling housing-related asthma triggers pales in comparison to health care costs such as emergency department visits, hospitalization, and missed school and work days. A Systematic Review of Home-Based Multi-Trigger Multi-Component Environmental Interventions to Reduce Asthma Morbidity, summarizes cost-benefit studies showing a return of \$5.30 to \$14.00 for each dollar invested, and a cost effectiveness of \$12 to \$57 per additional symptom-free day.³ See <http://www.thecommunityguide.org/asthma/multicomponent.html> for more information.

An improvement in health outcomes and associated savings should be incorporated in your local evaluation plan to document how your healthy homes program contributes to containing health care costs by preventing housing-related disease and injury.

Choose Evidence-Based Interventions

For many interventions, the evidence on clinical and environmental health benefits is well established. For others, further research and field testing is needed. The World Health Organization conducted an extensive review of the health impacts of inadequate housing.⁴ The CDC and the National Center for Healthy Housing convened a group of experts to review scientific findings on the effect of housing interventions on improved clinical and environmental health outcomes (Figure 5.1).⁵ The resulting report focused on five broad areas:

- **Indoor Biological Agents Interventions.** Studies related to allergens, dust mites, asthma, cockroaches, domestic animals, mice, and rats.
- **Interior Chemical Agents (Toxins) Interventions.** Studies related to water and air pollution, integrated pest management (IPM), pesticides, safe chemical storage, particulate matter, filtration, ventilation, volatile organic compounds (VOCs), formaldehyde, organic chemicals, radon, and lead.
- **External Exposures (drinking water and sewage treatment).** Studies related to exposures from the water supply, drinking water, in-home filtration, wastewater treatment, sewage, waste management, water pollutants, purification, and water filters. (Not covered in this Manual.)
- **Structural Deficiencies (injuries and safety).** Studies related to burns and burn prevention,

accident prevention, home injuries, protective devices, accidental falls, and fall prevention.

- **Intersection between Housing and Community.** Studies related to environmental justice, universal design, ordinances, law and law enforcement, and public policy.

Intervention Costs

An Evaluation of HUD's Healthy Homes Initiative: Current Findings and Outcomes⁶ identified the most common interventions and their costs. Of seven categories, the costliest was lead hazard control, with an average per unit cost of \$5,312 (including labor and materials). The least costly was education, with an average total cost of \$211 per unit (Table 5.1). Because costs and activities vary widely, it is important for programs to develop local cost databases, including relevant units of measurement, such as dollars per linear or square foot. It is also important for programs to evaluate benefits as well as costs. For example, one program

Table 5.1 Average Cost^a of Interventions per Housing Unit^{b,c}

Intervention Category	Cost per Housing Unit (Average)
Allergen reduction (n=17)	\$1292
Education (n=16)	\$211
Injury prevention (n=14)	\$233
IPM (n=14)	\$290
Lead hazard control (n=8)	\$5312
Moisture control (n=13)	\$1272
Weatherization (n=8)	\$2266
Average total cost per unit for all interventions (n=10)	\$3705

^aBenefits not included in cost estimates. Average cost includes both cost of materials and labor. Some costs are capped by the relevant program and may not be related to correction of all hazards or deficiencies.

^bNumbers presented in the table include both estimated and actual quantities provided by healthy homes programs. Of 44 healthy homes programs, 33 reported their numbers were estimates.

^cn=number of programs surveyed.

Source: HUD, 2007, p. ES-5.

Figure 5.1 Rating of Housing Intervention Effectiveness

Housing Interventions and Health panelists rated interventions according to:

- Sufficient evidence to consider the intervention effective;
- Promising intervention that needs more field evaluation;
- Intervention that needs more formative research; and
- Intervention with no evidence of effectiveness.

installed weather stripping and sealed ductwork as part of its weatherization activities while another replaced windows.

Principle #1: Keep It Dry

Review of the Evidence

Ventilation and moisture control are typically related. Both ventilation and dehumidification help to reduce humidity levels and exposure to dust mites. A national survey found the use of a dehumidifier predicted lower levels of some asthma triggers and mold.⁷ Additionally, installation of a whole-house mechanical ventilation system can reduce humidity, thus decreasing dust mites and improving clinical outcomes.^{8,9} Effective dehumidification in temperate climates can be achieved with air conditioners and/or dehumidifiers.¹⁰ In climates with high humidity, whole-house ventilation has been less effective.^{11, 12, 13} Climate zone must therefore be considered when making decisions about dehumidification.

Ventilation can improve indoor air quality when the outdoor air has lower levels of humidity and contaminants than the indoor air. Conversely, families in housing near pollution point sources such as industrial sites, high-pollen forested sites, and high-traffic roadways may need to filter or otherwise clean the outdoor air that enters the home environment.

Structural Interventions

Structural deficiencies related to moisture include water intrusion through the building envelope, plumbing leaks, drainage problems, and condensation. Key structural control methods are shown in Figure 5.2. Chapter 4 identifies a number of structural factors central to moisture control and how to assess when these controls have failed. The HUD/CDC Healthy Housing Reference Manual describes maintenance practices, proper insulation, and how to prevent moisture intrusion from a home's foundation, walls, and roof. The Reference Manual also provides information on the operations and maintenance of plumbing systems, venting requirements for plumbing systems, and methods to conserve water.

Figure 5.2 Key Structural Controls for Moisture

1. Limit water entry (e.g., maintain gutter systems).
2. Dehumidify damp spaces such as basements.
3. Repair leaks and assure that drains work properly.
4. Clean or properly remove wet or moldy building components.
5. Manage ventilation systems so that moisture is removed at the source.

Finished basements require special consideration regarding moisture control. In general, such spaces should not use sheetrock or paneling to cover exterior walls or wall-to-wall carpeting, both of which can lead to moisture and mold problems. Capillary breaks are discussed below as one way of controlling moisture in basements.

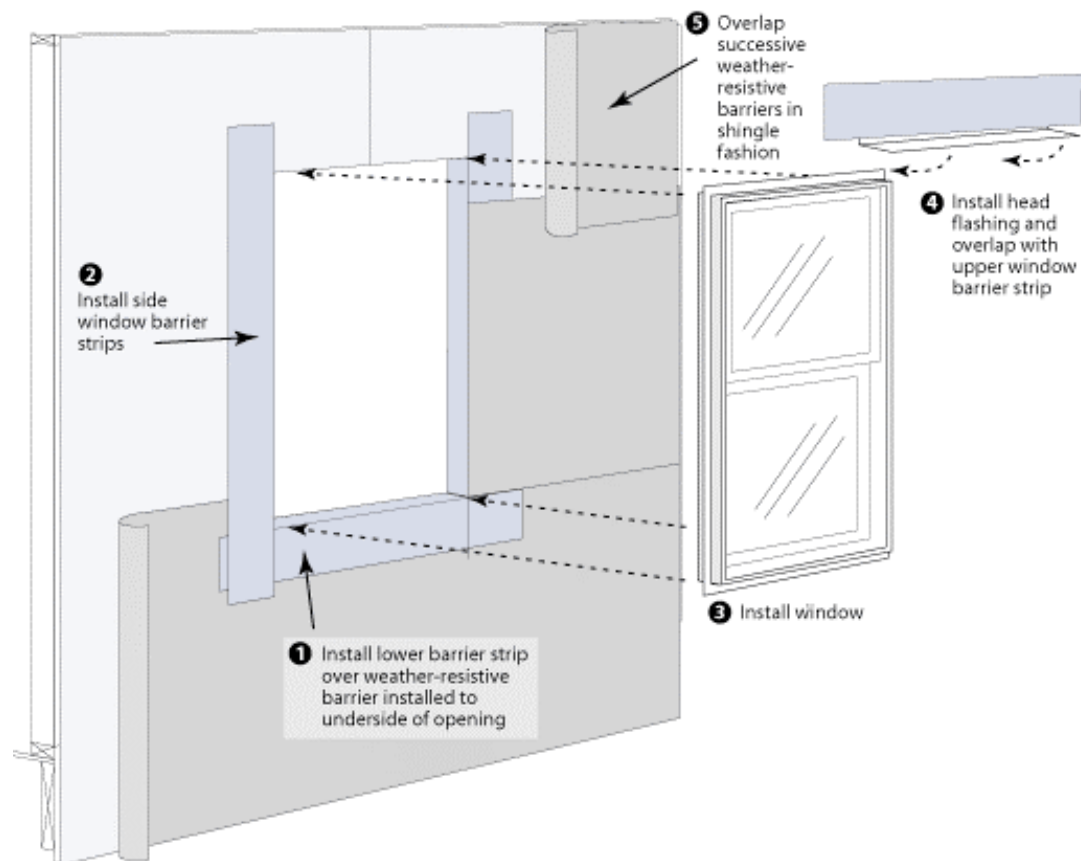
Controlling Building Envelope Leaks

Ensuring that roofs, walls, and foundations shed water effectively helps to control leaks. Absence or deterioration of flashing is a common building deficiency associated with water leakage through the building envelope. Flashing refers to thin continuous pieces of sheet metal or other impervious material installed to prevent water from passing into a structure through an angle or joint (Figure 5.3).

When new building components such as windows are installed, they should be accompanied by pan flashing to shed water away from the wall penetrations and prevent water from entering the structure. Flashing at the base of structures should allow water that has been repelled by the flashing to escape the plane of the building surface. The principle of flashing should be extended to all penetrations in structures. In other words, all of them should be sealed to prevent moisture as well as pest incursion into the living space.

Maintaining proper grading around a foundation and preventing erosion that can lead to pooling of water helps prevent moisture intrusion into

Figure 5.3 Window Flashing



Source: http://www.energysavers.gov/your_home/windows_doors_skylights/index.cfm/mytopic=13470

basements and reduces the need for expensive foundation waterproofing and excavation. This practice also promotes the durability of the structure by reducing the prospect of settling, which can sometimes lead to cracks. Specific interventions are discussed below.

- In new construction, install capillary breaks around interior foundation walls to prevent water from “wicking” up from the ground and into the building through capillary action. Capillary breaks can also be installed in existing construction. Capillary breaks are needed to prevent vertical moisture movement, such as from the foundation wall up into the wall or floor framing (only practical in new construction) and horizontal moisture movement, such as soil moisture moving through the foundation wall into the basement or crawl space. This is accomplished by water-proofing or damp-proofing the exterior side of the foundation wall during construction. While usually very expensive to carry out as a retrofit, it is sometimes the most cost-effective

way to control moisture in existing homes when combined with perimeter drainage and proper grading away from the structure. Construction information on capillary breaks is available in EPA’s Indoor airPLUS construction specifications (epa.gov/indoorairplus/construction_specifications.html).

- In existing structures, a retrofit with French drains or other means of diverting water away from foundations may be needed.
- Gutters and downspouts should drain water from the roof to the ground with no breaks in the system. Drainpipes or splash blocks should redirect water from the downspouts away from the foundation, but care should be taken not to direct the water near the foundation of the neighboring building.
- Planter boxes, decks, or other outdoor structures should be placed so that they do not obstruct rainwater flow or snowmelt from the foundation (Appendix 5.1).



Condensation can occur when warm, moist air comes in contact with a cold surface. This can lead to mold and other problems, creating health hazards and building decay. Sometimes condensation occurs within walls, ceilings and floors that separate the outside unconditioned air from the conditioned air inside the structure as warm moist air travels through the cavity. Crawl spaces, attics, and exterior walls can be affected. In some cases a vapor retarder (often called a vapor barrier) is recommended to inhibit condensation from the movement of moisture-laden air into walls, ceilings, and floors. Placing a heavy plastic sheet on the bare ground in a crawl space, carefully sealing any seams, and sealing the plastic to the foundation can minimize moisture movement from the crawl space into the structure.

Note that vapor retarders require careful thought. If an insulated wall has materials on both the interior and exterior surfaces that retard vapor movement, moisture can become trapped within the wall cavity and cause a serious problem. Walls should be designed so they dry in at least one direction.

Similarly, cold water pipes located in areas where the air is warm should be insulated to prevent condensation. One way of detecting this problem is to look for areas of discoloration where condensation from pipes has dripped onto a lower surface. The same principle applies to ductwork that carries warm or cold air through air zones with a high temperature gradient. Ductwork should be sealed and well insulated in unconditioned spaces to prevent

condensation. Insulation should be applied to the exterior of the ductwork, not the interior. While insulation of ductwork is a simpler matter in new construction, poor insulation of ductwork in existing housing can result in condensation inside ductwork and become a significant breeding ground for mold and other biological agents.

Ensure that windows are adequately installed, caulked, and insulated to prevent condensation—a cause of both mold and lead-based paint failure. Replacing old single-pane windows with modern double- and triple-pane windows can effectively eliminate window condensation problems. This intervention may be cost-prohibitive for healthy homes programs unless funds can be leveraged through partnerships, from lead hazard control and/or weatherization programs, or the private sector.

Reduce moisture sources with high quality exhaust fans in bathrooms and kitchen, and proper venting of dryers, to substantially reduce the likelihood of condensation on windows or walls. Finally, eliminate insulation voids in walls and ceilings since cold interior wall surfaces in the winter can lead to condensation and mold.

Prompt Repair of Plumbing Leaks

How water and moisture leave a home are as important as how they enter. Plumbing is often overlooked as a significant source of moisture because leaks can be slow or undetected. Drain traps can degrade or dry over time if the drain trap is not kept full of water. Basement floor drain traps should be kept full by adding water periodically to prevent harmful soil and/or sewer gases from being emitted.

Safe Cleaning or Removal of Wet or Moldy Items

Failure to correct the source of moisture that produced mold contamination guarantees the eventual failure of mold remediation efforts. There are established procedures for safely removing wet and moldy building materials and furnishings, typically involving minimizing the disturbance of such materials to prevent mold spores from becoming airborne.^{14, 15, 16} Projects requiring large areas of mold decontamination (e.g., more than ten square feet) may warrant the use of a mold mitigation professional. Improper

solutions, such as blowing air over mold contaminated items, can increase exposures and may do more harm than good. Individuals attempting to mitigate mold problems should be trained to prevent exposure to mold during the elimination process through the use of respiratory, eye and skin protection equipment.

Appropriate Design, Installation, and Management of Heating, Ventilation, and Air Conditioning (HVAC) Systems

Many kitchen fans in older homes simply recycle air coming from stoves and ranges rather than vent it to the exterior of the building. Some current building codes for new construction require that kitchen range hoods be exhausted to the outside. Check by looking above the fan or range hood to see whether there is ductwork and examining the exterior wall for a flap that would exhaust the air. Installers often forget to remove the manufacturer's tape on the flap, so it is important to ensure that the flap is not only present but functioning properly. Bathroom exhaust fans and clothes dryers must be vented to the outside.

In general, a home's relative humidity should be kept in the 30–50 percent range. Filters in clothes dryers, kitchen ranges, furnaces and bath exhausts should be cleaned and/or replaced to ensure air flow is adequate and moisture does not accumulate on the dust in the filters. Instructions on when and how to clean and replace filters properly should be part of a program's education intervention strategy.

Air conditioning or dehumidifying systems need to be checked regularly and cleaned to ensure that condensate drains do not become blocked. Blockage results in leaks from the drainage pans onto surfaces that may not be visible. Condensate pans should be properly sloped so that water runs to the drain and does not pool in other areas. Cooling coils need to be kept clear and clean to prevent blockage as well as prevent high fuel consumption due to lower heat transfer. Homeowners/residents or maintenance personnel can take care of this for window air conditioners, but for central air conditioning systems, a licensed contractor is generally needed.

Some heating, ventilation, and air conditioning systems (HVAC) are equipped with humidifiers,

especially in northern climates where indoor winter air becomes dry. In other cases, individual rooms may be equipped with portable humidifiers. In both cases, the water supply, water tank, and water wheels or other distribution systems should be kept clean. If the systems are not used for some time, they can become breeding grounds for biological agents, including mold, bacteria, and viruses. Very dry conditions in the house may be due to dry cold air entering the home during the winter. Proper air sealing may remove the need for a humidifier.

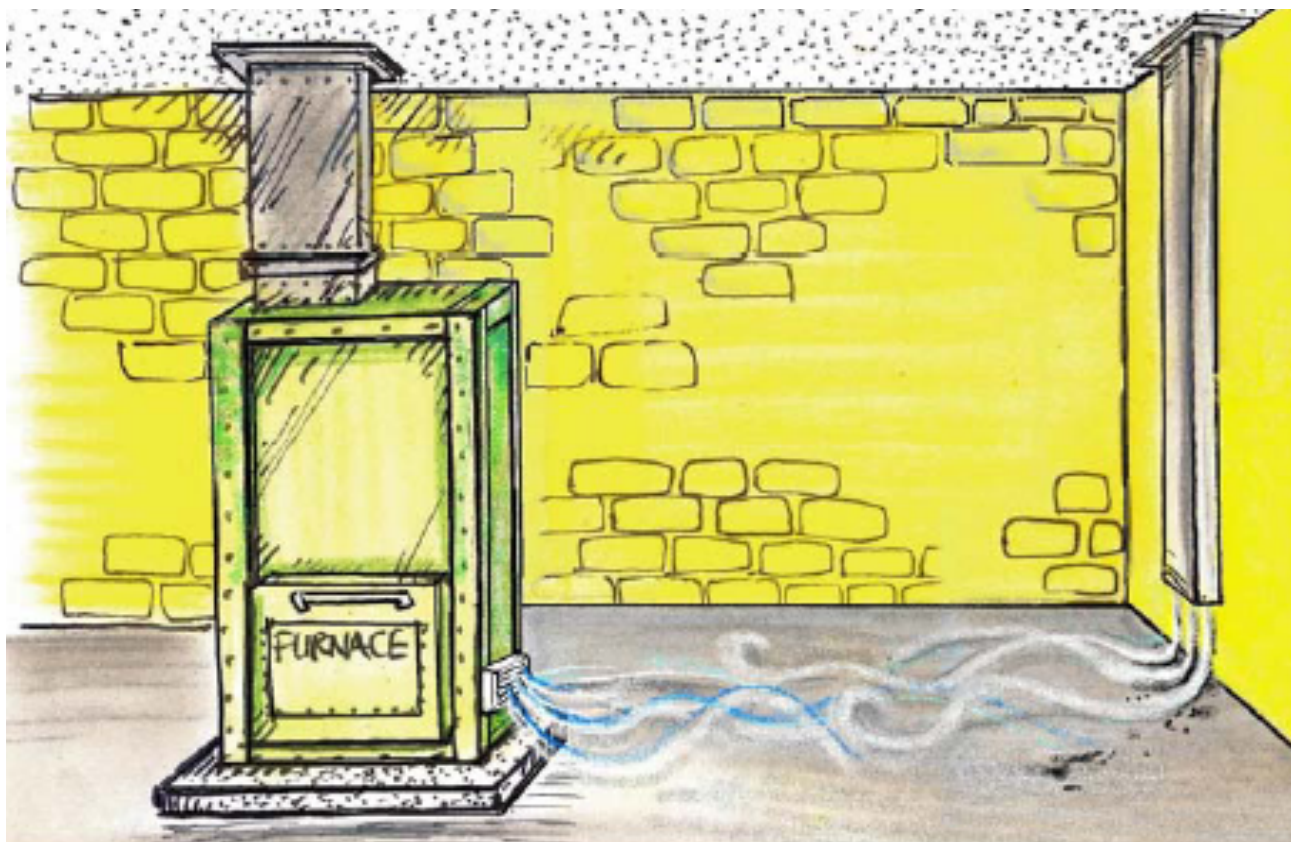
If an area has become wet, drying is typically the first step in remediation after eliminating the moisture source (Figure 5.4). However, some forms of drying can exacerbate the problem. Blowing high-velocity air streams over surfaces contaminated with extensive mold can cause mold spores and fragments to become airborne, where they can be inhaled readily or contaminate other surfaces. Use of dehumidifiers, personal protection and other measures can help to avoid these problems. In some cases, it may be necessary to discard contaminated items that cannot be properly cleaned. If the extent of damage is extensive, trained professionals should address the problem. It is equally as important to identify the moisture source and to make needed repairs to prevent reoccurrence. During catastrophic water events (e.g., pipe breaks, water heater failure, flooding), time is of the essence. Typically, water needs to be removed within 24–48 hours, after which mold begins to develop. Many restoration companies are now available to extract water following a flood using dehumidifiers, fans, and other tools.

Figure 5.4 Remediation Guidance

Mold and moisture remediation guidelines are available from the following organizations:

- EPA: <http://www.epa.gov/mold/moldcleanup.html>.
- New York City Health Department: <http://www.nyc.gov/html/doh/html/epi/moldrpt1.shtml>.
- AIHA: <http://www.conferencemedia.net/store/stores/aihce/american-industrial-hygiene-conference-and-expo-2009/perspectives-on-the-aiha-green-book.html>.

Figure 5.5 Unhealthy Heating System Using Basement Air



The illustration shows returning air entering the basement air, then supplying the furnace with air distributed throughout the house. Figure 5.6 shows a simple fix that avoids contamination of supply air.

For some moisture problems, changes to the HVAC system may be needed. For example, a ventilation system that draws air from a moist basement instead of a living area may result in dispersing moisture and mold throughout the house (Figures 5.5 and 5.6). This type of system is sometimes called “the Cleveland Drop” because it was first identified in a number of Cleveland-area houses that were investigated for mold and moisture problems. A solution is to ensure that the air supplying the furnace is supplied from the exterior or from a living area, rather than the basement. Leaky ductwork can also lead to problems because it may draw in air from unconditioned spaces. Ductwork should be sealed to prevent such leaks. For new construction, information is available in EPA’s Indoor airPLUS construction specifications: www.epa.gov/indoorairplus/construction_specifications.html.

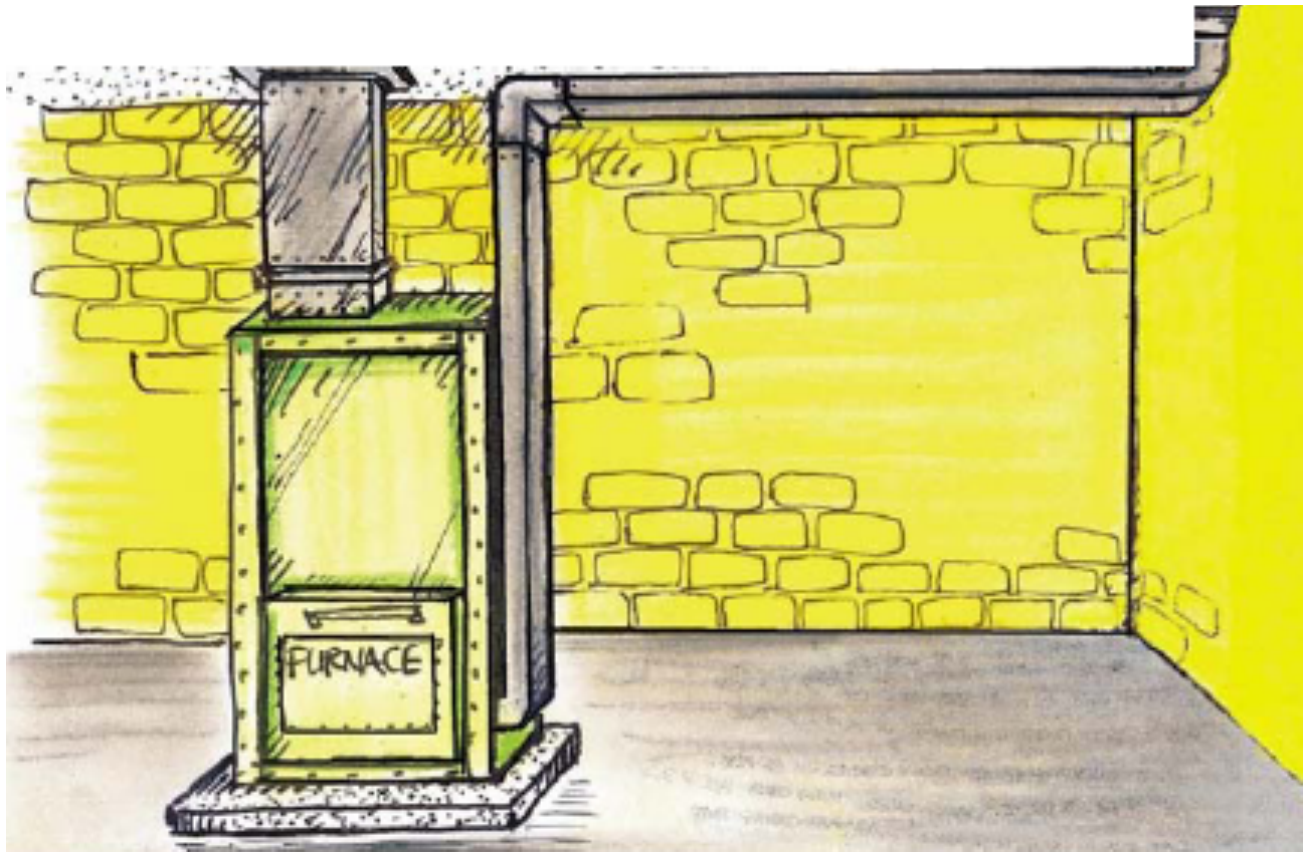
Reporting Moisture and Leak Problems

Owner occupants and renters should be encouraged to conduct regular visual assessments to identify leaks and condensation. Tenants need to have confidence that requests for minor repairs and reporting maintenance needs are taken seriously or they will fail to report problems when they are relatively easy to correct. Tenant failure to promptly report problems and property owner failure to respond represent major problems in economically distressed rental housing. Clarifying roles and expectations and providing incentives for responsible behavior are important tools for healthy homes programs.

Principle #2: Keep It Ventilated

A number of housing defects and conditions leading to health problems can be corrected by

Figure 5.6 Healthy Heating System Using Outdoor Air or Air From Living Spaces



Figures 5.5 and 5.6 courtesy of Environmental Health Watch/Cuyahoga County Board of Health, Cleveland, Ohio

proper ventilation. However, source control—eliminating certain products or selecting materials that have low emissions, thereby limiting the chemicals released into the air we breathe—should precede any changes to ventilation. Using building materials, carpeting, and furnishings that have no or low levels of formaldehyde or other VOCs is recommended. The California Air Resources Board has rules limiting the amount of formaldehyde that off-gases from building products such as pressed wood and particle board.¹⁷ Some sources of hazards, such as radon, however, can only be controlled by specialized systems.

Review of the Evidence

As noted under Keep It Dry, ventilation is usually critical to moisture control. Failure to provide adequate fresh air supply and proper distribution can also lead to a variety of adverse health conditions. Two recent studies, one

related to new construction and the other to housing rehabilitation, demonstrate that statistically significant health improvements can be associated with improved ventilation when conducted in association with other building improvements.^{18, 19} Standards for applying ventilation to the home can be found in American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standards 62.1 and 62.2.

Figure 5.7 Ventilation Interventions

- Remove airborne contaminants through proper exhaust ventilation.
- Supply fresh air through dilution ventilation.
- Test for and conduct radon remediation as needed.

Structural Interventions

There are two types of structural interventions: (1) local exhaust ventilation to remove pollutants created at a source, such as moisture vapor from a bathroom or cooking fumes from a kitchen range; and (2) general ventilation for the whole house that helps lower pollutant levels. Local exhaust ventilation systems capture a contaminant and remove it before it enters the entire housing unit. General ventilation provides fresh air to reduce the chance that concentrations of contaminants raise to hazardous levels. Houses should have both types of ventilation.

Local Exhaust Interventions

All kitchens and bathrooms should be equipped with exhaust systems to remove moisture and odors. Although some building codes permit windows to be used for ventilation, windows are unlikely to be open during the cold winter or hot summer months. Exhaust systems are therefore best practice. Local systems should be exhausted to the exterior, not into a building chase, attic, basement, crawl space or wall cavity. All clothes dryers should be exhausted to the exterior. Energy conservation devices that permit warm moist air from clothes dryer exhaust to be re-circulated back into the house should not be used.

All combustion burning appliances, such as fuel-fired space heaters, water heaters, furnaces, boilers, fireplaces, and gas ranges/ovens should exhaust to the exterior. If new equipment is installed, it should be direct-vent or power-vented equipment. A direct vent uses a double pipe to carry both exhaust and supply air (Figure 5.8). When additional exhaust systems are installed, the supply air (makeup air) should be installed or planned. If no makeup air is provided, serious problems can occur from the creation of negative pressure within the home.

General Dilution Ventilation and Heating System Interventions

Ventilation systems should first ensure that the supply air is contaminant-free and does not pass over standing water or use air from garages or high traffic areas. When dilution ventilation systems for fresh air are designed or retrofitted,

Figure 5.8 Direct Power Vent Increases Energy Efficiency and Helps Avoid Back Drafting Problems



Figure 5.9 Air Handler Filter Ratings

MERV Ratings		
MERV	PARTICLE SIZE (µm)	TYPICAL CONTROLLED CONTAMINANT
1 – 4	>10.0	Pollen, sanding dust, textile and carpet fibers
5 – 8	3.0 – 10.0	Mold, spores, hair spray, cement dust
9 – 12	1.0 – 3.0	Legionella, lead dust, welding fumes
13 – 16	0.3 – 1.0	Bacteria, most tobacco smoke, insecticide dust, copier toner
17 – 20	≤ 0.3	Virus, combustion particles, radon progeny

they should comply with standards established by ASHRAE. Standard 62.1 is the standard for multifamily buildings and 62.2 is for low-rise and single-family dwellings. ASHRAE recommends the amount of fresh air needed based on the size of the building and number of occupants. Heat recovery systems can decrease the energy needed to temper fresh air. A high efficiency heat recovery system transfers the heat in exhausted air to the incoming untempered fresh air supply to reduce added energy costs.

Air filters in ventilation systems need to be changed frequently because a dirty filter reduces air flow. Furnace filters that remove small particles more efficiently are now available and rated by ASHRAE according to their Minimum Energy Rating Value (MERV) (Figure 5.9). MERV ratings of 5–8 mean that the filters control the majority of particles of 3 microns or greater in size. However, particulates smaller than 2.5 microns are now subject to EPA regulation in ambient air and include asthma triggers such as environmental tobacco smoke.

Programs should select the MERV-rated filter geared to indoor air contaminants that trigger asthmatic reactions and meeting manufacturers' recommendations. Ideally, your program should consider recommending a filter with a MERV rating above eight, depending on the capabilities of the air handling system. Check with the equipment manufacturer or HVAC contractor to make sure the new filter will not put excess strain on the system or create negative pressure problems.

Principle #3: Keep It Pest-Free

Pests are an important health issue for many residences, but can be particularly troublesome in multifamily housing where infestations can quickly spread from one unit to the next. Pesticides, while sometimes helpful, also pose risks. Pests can be managed more effectively with fewer pesticides through Integrated Pest Management (IPM) (Figure 5.10). IPM is an integrated preventive approach that targets conditions conducive to pests rather than simply treating the symptoms (i.e., pests) with pesticides. In short, IPM:

- Is more effective at eliminating pests.
- Prevents pest infestations in the future.
- Is expected to reduce pesticide exposures to residents and staff, which is important to children, older adults and chemically sensitive individuals.
- Can save time, money and energy.
- Can improve quality of life for residents.

Figure 5.10 Principles for Keeping It Pest-Free

- Educate residents/tenants
- Reduce moisture
- Remove harborages
- Eliminate food sources
- Use low toxicity pesticides as needed
- Monitor

Principles of Integrated Pest Management (IPM)

IPM is a common-sense approach to managing pests while reducing use of harmful pesticides. It focuses on getting rid of the food, water and shelter that pests need to survive. IPM works because integrated approaches for pest management are more effective in the end than a single one like spraying pesticides. IPM is always a team effort among the building manager, landlord, maintenance staff, residents, and pest management professional. Everyone has a role to play and must communicate and cooperate.

As a decision-making process to manage the control of pests and disease vectors,²⁰ IPM is a departure from the traditional practice of trapping, spraying, and poisoning. In addition to other factors, it uses the least toxic pesticides in a way that controls human exposures to possible harm. For example, use of gel baits to kill cockroaches along with sealing cracks and crevices are often key components of IPM. It considers the behavior and ecology of the specific pest, where it is active, and how environmental changes may influence the pest. In so doing, IPM has a strong educational component because the environment includes the behavior of occupants. Education is indeed a critical component, and the evidence to date documents that IPM is effective in controlling pests, reducing exposure to pesticides, controlling pest access, reducing moisture, and is equivalent to or costs less than traditional pest control methods over the long term. Figure 5.11 lists key elements of IPM.

Review of the Evidence

Several rigorous studies have demonstrated the effectiveness of IPM in reducing exposure to cockroaches.^{21, 22, 23} Arbes found that roach allergen levels were significantly reduced in beds and kitchens with IPM, and the levels in the beds dropped below thresholds for both asthma sensitization and exacerbation. Wang and Bennett showed a significantly greater decrease in roach counts with IPM compared to gel bait alone. Miller and Meek found that while IPM was initially more costly, it was much more effective in reducing cockroaches compared to

Figure 5.11 Key Elements of Integrated Pest Management

HUD's Office of Public and Indian Housing Notice PIH-2007-12 (HA) defines the key components of an IPM program as:

- Communicating the Housing Authority's IPM policies and procedures to all building occupants, administrative staff, maintenance personnel, and contractors.
- Identifying (1) pests and (2) environmental conditions that limit the spread of pests, including the presence of pests' natural enemies.
- Establishing an ongoing monitoring and record keeping system for regular sampling and assessment of pests, surveillance techniques, and remedial actions taken, including establishing the assessment criteria for program effectiveness.
- Determining, with involvement of residents, the pest population levels—by species—that will be tolerated, and setting action thresholds at which pest populations warrant action.
- Improving sanitation, waste management, mechanical pest management methods, and/or natural control agents that have been carefully selected as appropriate in light of allergies or cultural preferences of staff or residents.
- Monitoring and maintaining structures and grounds (e.g., sealing cracks, eliminating moisture intrusion/accumulation) and adding physical barriers to pest entry and movement.
- Developing an outreach/educational program and ensuring that leases reflect residents' responsibilities for (1) proper housekeeping; (2) reporting presence of pests, leaks, and mold; and (3) cooperating with specific IPM requirements such as obtaining permission of Housing Authority management before purchasing or applying any pesticides.
- Enforcing lease provisions regarding resident responsibilities such as housekeeping, sanitation, and trash removal and storage.
- Using pesticides only when necessary, with preference for products that, while producing the desired level of effectiveness, pose the least harm to human health and the environment, and, as appropriate, notifying management before application.
- Providing and posting "Pesticide Use Notification" signs or other warnings.

Also see: GSA Guidelines for Structural Pest Control Operations: http://schoolipm.ifas.ufl.edu/doc/bus_prac.html

traditional pesticide treatment.²⁴ Useful case studies describing successful IPM programs in affordable housing can be found at: <http://www.healthyhomestraining.org/ipm/Studies.htm>.

Different types of pests depend to some extent on climate, locale, and type of building. However, the methods of detecting pests are fairly similar and are described in Chapter 4. Most states require that pesticide applicators be trained, certified, and licensed. Contract specifications, standard operating procedures, landlord and tenant training videos and educational materials are available at: <http://www.bphc.org/programs/cib/healthyhomescommunitysupports/healthyhomes/healthypestfreehousing/Pages/Home.aspx> or from <http://www.stoppests.org>.

Structural Interventions

Typical structural modifications used in implementing IPM include the following:

- Copper mesh screens to seal holes. Steel wool may rust and should not be used.
- Use of low VOC caulks or sealant to seal penetration openings, which also prevents moisture infiltration.
- Correction of all water leaks.
- Use of trash cans with tight-fitting lids.
- Regular cleaning of trash chutes.
- Elimination of exterior harborage, including sealing rat burrows and placing trash

dumpsters on concrete pads at least 50 feet away from the building.

- Information on controlling bedbugs can be found in the National Center for Healthy Housing report: What's Working for Bed Bug Control in Multifamily Housing: Reconciling best practices with research and the realities of implementation, which can be found at http://www.nchh.org/Portals/0/Contents/Bed_Bug_Report_2=12-10.pdf.

Rental Policies and Use of IPM Professional Services

In addition to structural modifications, programs need to establish guidelines for rental property owners and property managers about which services will be provided for pest management, responsibilities of maintenance staff in the short-term, and conditions under which trained IPM professionals should be engaged. Practices, roles and responsibilities vary by locality. However, all healthy homes programs should have guidelines addressing the following issues.

- Define who is responsible for applying low-toxicity pesticides (such as boric acid) along insect runways.
- Determine whether the program or property owner/property management firm will supply trash cans for tenants' use. Some programs have provided trashcans with tight-fitting lids for interior use by tenants.
- Establish a monitoring system to ensure the effectiveness of IPM. A monitoring system

Environmental Health Watch, a nonprofit organization in Cleveland, Ohio that is involved in community environmental health programs, reports that when tenants observe the immediate effect of flushing and vacuuming cockroaches, they are motivated to improve their daily cleaning practices. In many cases, residents whose homes have a history of pest problems feel it is useless to try to do anything. However, once they see results, they are willing to establish partnerships and accept division of labor to deal with pest management.

typically includes observation of sticky traps to determine if pests are re-emerging.

Pest management professionals should be used and can be certified by Green Pro, Green Shield Certified, or Eco-wise (see http://www.healthy-homestraining.org/ipm/PMP_comparisons.htm).

Principle #4: Keep It Safe

Key Principles of Injury Prevention

Fatal and nonfatal injuries are often caused by structural and other housing deficiencies ranging from construction, design, and installation issues as well as lack of monitoring or maintenance. Structural deficiencies in a home can account for falls, smoke inhalation from fires, burns and scalds, carbon monoxide and other forms of poisoning, drowning, and other injuries. See Figure 5.12 for ways to prevent certain injuries.

Healthy homes programs should focus on populations at greatest risk, including children and older adults. While safety hazards can exist in any home, other threats may be seasonal or regional in nature. For example, swimming pool risks may be higher in summer. Disaster preparedness in the home may take on added importance during tornado or hurricane season. While infrequent, healthy homes programs should help prepare the families for these emergencies throughout the year. Programs in earthquake-prone areas may need to consider other actions.

Figure 5.12 Principles for Keeping It Safe

- Educate residents/tenants.
- Prevent falls by installing railings on stairways and grab bars in bathrooms.
- Keep hot water temperature maximum at 120 degrees.
- Ensure that smoke and carbon monoxide alarms are working and in the right locations.
- Store chemicals and medicines properly.

Falls

Review of the Evidence

Falls account for 45 percent of all injuries in the home that require medical attention.²⁶ Residential injury-related deaths for persons aged 65 years and over account for approximately 60 percent of all household deaths due to falls.²⁷ Structural residential hazards associated with falls among older adults include lack of handrails on stairs, lack of grab bars and non-slip surfaces in the bathroom, tripping or slipping hazards (e.g., throw rugs without nonskid backings), waxed flooring, inadequate lighting, and the presence of electrical or telephone cords in the walkway.²⁸ Individual behaviors and physical ability levels also are important factors contributing to falls among older adults.²⁹

Falls also are a major cause of nonfatal injury in children and result in an estimated 2.7 million emergency room visits each year.³⁰ Residential structural hazards associated with falls among children include a lack of safety devices such as safety gates and window guards, uncarpeted or concrete floors, missing or damaged window locks or catches, structural defects (e.g., inadequate spacing and height of railings, lack of handrails), and insufficient lighting over stairs and in other areas.³¹

There is evidence that certain structural modifications, such as installation of handrails,

grab bars, and improved lighting, can reduce falls among older adults.^{32, 33} Home modifications, including installation of stair rails, non-slip mats, and night lights, resulted in 30 percent decrease in falls compared to homes receiving no modifications. Additionally, handrail installation and improved floor coverings resulted in a 10 percent decrease in falls.³⁴ Yet another study showed that installation of grab bars and improved lighting also resulted in significantly fewer falls.³⁵

A community-wide program to provide window guards in high-risk apartments demonstrated that window guards reduce childhood morbidity and mortality from falls. Falls declined 50 percent in the two years after the program's inception.³⁶ There is also a reduced risk of injury in homes with fitted stair gates and other safety devices.³⁷ A review of 37 studies showed that home education produced a statistically significant increase in the odds that a home would have a fitted stair gate and a modest, non-significant increase in the prevalence of installed window locks and other window guards.³⁸ Building codes that require window guards, safe stair and balcony design, and other modifications are likely to be effective for fall prevention.

Proper lighting has also been associated with reductions in falls and also in depression.³⁹ Installation of nonskid surfaces, such as abrasive strips on porch steps and use of throw rugs with nonskid backings, can help to prevent skids and falls.

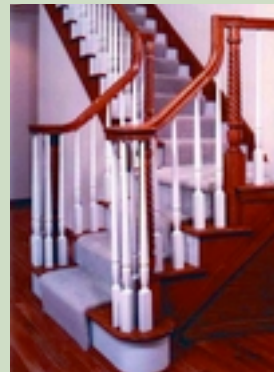
Figure 5.13 Grab Bars, Window Guards, Stair Railings, and Stair Gates.



Grab bars can help to prevent falls in showers and baths.



Window guards help to prevent falls.



Stairs should have properly designed hand rails.



Stair gates can help to prevent falls by young children.

Structural Interventions

Before implementing structural changes, programs should consult local codes to ensure that the modification does not conflict with local laws and regulations. Programs can reduce fall hazards by adopting the following protocols:

- Ensure that interior and exterior stairs and railings are in good repair. Ideally railings should be continuous (i.e., no breaks in the railings from one stairwell to the next) and they should be located on both sides of the stairwell.
- Install window guards and safety gates for households with young children.
- Install grab bars in baths, showers, and near toilets for households with older adults.
- Ensure that toilets, showers, and bath entries are at an appropriate height.
- Use nonskid surfaces in bathrooms.
- Increase lighting in stairwells, entryways, and hallways/passageways.

A home safety checklist for preventing falls can be useful for resident education, and is discussed at the end of this chapter.

Burns and Scalds

Review of the Evidence

In 2006, U.S. fire departments responded to 412,500 residential fires that resulted in 2,580 deaths, 12,925 injuries, and nearly seven billion dollars in property damage (Figure 5.14).⁴⁰ Groups at increased risk of fire-related injury and death include infants and young children (0–4 years) and the elderly (75 years and older), African Americans, Native Americans, low-income Americans, rural residents, and those

Figure 5.14 Fire Facts

Residential fires resulted in over 2,500 deaths, nearly 13,000 injuries, and \$7 billion in property damage in 2006. Many fatalities and burn injuries can be prevented by use of properly placed smoke alarms, implementing evacuation plans and installing anti-scald and anti-burn devices.

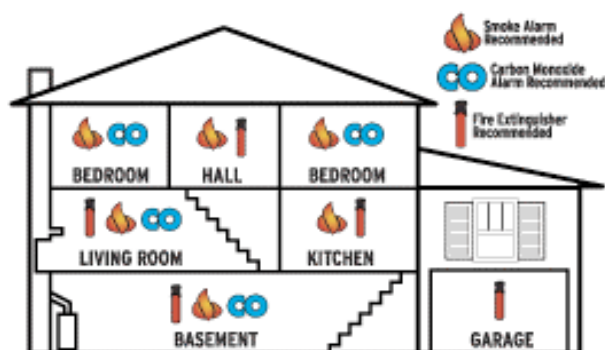
living in manufactured (e.g., mobile) homes and substandard housing.^{41,42} The lack of functioning smoke alarms near or inside bedrooms and on every floor of a house, and lack of adequate escape routes in the event of a fire^{43,44} are the primary residential hazards associated with fire-related injuries. Other important causes of fire-related injury include faulty wiring, defective appliances, misuse and poor maintenance of electrical appliances, lack of arc fault circuit interrupters (AFCIs), and overloaded circuits and extension cords.⁴⁵

Structural Interventions

Smoke alarms. Installing working smoke alarms is one of the most important intervention strategies to prevent fatalities and burns from fire (Figure 5.15). Be sure to consult local building codes.

Numerous studies demonstrate that working smoke alarms in the home reduce death and injuries from residential fires.^{46,47,48,49} Homes with working smoke alarms have a 40–50 percent lower fire death rate compared to homes without working smoke alarms.⁵⁰ A total of 70 percent of all home fire deaths occur in homes without working smoke alarms.⁵¹ To have “working” smoke alarms, they must be properly located (outside sleeping rooms on each level) and properly and regularly maintained by replacing batteries at established intervals. Installing hard-wired smoke alarms (with a battery back-up) or alarms with sealed, ten-year lithium batteries is preferable as they reduce the need for annual maintenance. Fire extinguishers should be present and checked at least yearly.

Figure 5.15
Smoke and Carbon Monoxide Alarms



Evidence points to findings that education combined with community-based installation of smoke alarms reduces fire-related injuries in high-risk homes.⁵² Further, community-based programs that install smoke alarms are significantly more effective than community-based programs that give away smoke alarms but do not install them.

Healthy homes programs should recommend that families adopt and practice a formalized fire escape plan, including alternative means of egress, particularly from upper floors (see Figure 5.16). The plan should include a nearby but offsite regrouping meeting place.

Temperature controls for water heaters. In 1997, an estimated 12,400 children were scalded, nearly a quarter of the burns caused by hot tap water.⁵³ Most scald-related deaths occur in children younger than four years old.^{54, 55} Other

high-risk groups include the elderly and those with physical or mental disabilities.⁵⁶ Scald burns commonly occur from contact with hot foods or liquids and hot tap water, and are typically more severe from hot tap water. Most occur in the bathtub or shower, but may also occur in the kitchen or bathroom sink. Primary residential deficiencies associated with scalds include lack of anti-scald devices for showerheads and faucets (see Figure 5.17) and water heater thermostats set above 120° F.⁵⁷ New hot water heaters may be pre-set at higher temperatures and service companies may reset temperatures at higher levels than appropriate.

In addition to keeping water heater temperatures below 120° F, healthy homes programs should recommend installation of safety knobs for stoves and ovens to prevent burns (Figure 5.17).

Other Safety Interventions

Poisoning. Injuries and fatalities can stem from improper storage of household chemicals and medicines. When young children are present, cabinets should be equipped with childproof locks (Figure 5.17).

Residents should not use portable fuel-fired electrical power generators indoors because of carbon monoxide exposure. Stoves and ovens should not be used to heat the home. Attached garages should be sealed and/or placed under slight negative pressure with respect to the living space. Some observers advocate housing codes changes that require exhaust fans in garages. Healthy homes programs support all these

Figure 5.16
Fire Escape Plan

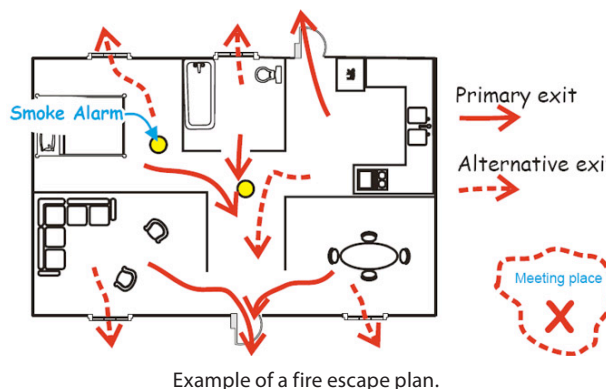


Figure 5.17 Anti-Scald Hot Water Faucets, Oven Knob Covers and Cabinet Locks



measures, plus installation of carbon monoxide alarms which can be located next to smoke alarms and are often available as a single device.

Carbon monoxide alarm. Similar to smoke alarms, carbon monoxide alarms should be placed on each floor of the house and adjacent to bedrooms.

Choke hazards. Securing ends of window curtain pull strings so that they are out of reach of children is an inexpensive yet effective measure to prevent choking hazards. Cord wind-ups are a simple intervention as well as cutting loops in pull strings a no-cost strategy for preventing strangulation.

Drowning and Pool Fencing. An average of 823 drowning deaths (across all ages) occurs in or on home premises yearly.⁵⁸ In 2004, for every child under 15 years who died from drowning, five additional children received emergency room care for nonfatal submersion injuries, which can result in brain damage and long term disability.⁵⁹ The risk of drowning is also high for adults 70 years and older. Forty-five percent of drowning cases occur in swimming pools and 33 percent in bathroom tubs and showers. Primary structural deficiencies associated with residential drowning include lack of barriers (e.g., having an unfenced

or uncovered swimming pool) and lack of pool or door alarms.⁶⁰ Drain vents for pools should always be kept clear. Four-sided (fully-enclosed) pool fencing significantly reduces childhood drowning (see Figure 5.18)^{61, 62, 63, 64} and performs significantly better than three-sided perimeter fencing. Note the pool fence with wire mesh that completely surrounds the pool in Figure 5.18. The height of the fence should comply with local codes.

Firearms control and security systems. Healthy homes programs should include information on keeping firearms and ammunition in a secure location away from children and teens. Owners should use trigger locks and store ammunition separately. This general rule also applies to knives, bows and arrows, and tools.

Home safety and disaster planning. Healthy homes programs should provide information on key components of a home emergency kit that can be easily transported in the event of evacuation. There are also materials available on what occupants can do to protect themselves during cleanup following floods, hurricanes, and other natural disasters. Arrange a place for rapid dissemination of such materials if such a disaster strikes. The Federal Emergency Management Agency provides information on disaster planning at www.fema.gov/plan/index.shtm.

Figure 5.18 Fully Enclosed Pool Fencing



Principle #5: Keep It Contaminant-Free

Asbestos

Inhalation of asbestos fibers causes cancer. If asbestos is maintained in an intact, non-friable condition within materials and is not disturbed, there is no opportunity for exposure. Typically, asbestos remediation takes place when there is a danger of fibers being released into the air. The remediation involves, either controlling airflows by putting the area under negative pressure and/or using glove bags or other containment systems that prevent fibers from getting into the air. Common sources of asbestos include pipe and boiler insulation, floor tiles, siding, vermiculite insulation, and roofing materials. Respiratory protection, proper waste disposal and special cleanup procedures, and air sampling are all part of asbestos abatement jobs. Individuals performing such tasks must be trained and certified. More information is available at <http://www.epa.gov/asbestos/pubs/pubs.html>.

Lead-based Paint Hazards

Reducing exposure to lead-paint hazards can be accomplished by numerous methods, including abatement and interim controls, such as keeping lead-based paint intact, covering bare soil with mulch, plantings, or other coverings, or hiring certified firms and workers to handle renovation, repair, and painting work in older housing. Lead-safe work practices and other methods of controlling lead-based paint hazards are detailed elsewhere^{65, 66} (see the “Keep It Maintained” section below).

Combustion Products

Combustion by-products include carbon monoxide, oxides of nitrogen, particulates and

other substances. Proper exhaust ventilation for combustion sources, including adequate makeup air, helps minimize entry of these gases into the living space (see ventilation section). Attached garages should be air sealed between the living space and garage. Carbon monoxide alarms will also help prevent harm from combustion products (see safety section). Regular servicing and maintenance of furnaces is essential because cracked heat exchangers are a source of combustion by-products.

Stoves should not be used for heating and all fuel burning appliances should be vented to the outside.

Volatile Organic Compounds (VOCs)

VOCs are a class of carbon-containing chemicals that become gases at room temperature and, when inhaled, can produce a variety of adverse health effects. Examples of VOCs include toluene, benzene, methyl ethyl ketone and paradichlorobenzene. They are present in cleaners, adhesives, carpets, air fresheners, mothballs and many other home products. To the extent possible, exposure to VOCs should be minimized by controlling or eliminating the sources. For example, air fresheners merely add these substances to indoor air without providing a benefit, and can conceal odors that indicate problems that should be addressed. Healthy homes programs should advise residents not to use air fresheners indoors.

Exposures to some substances like formaldehyde can produce sensitization, making even low levels of future exposures risky to health. (See ventilation section above for more detailed information.)

Products and substances containing VOCs, particularly fuels, gasoline, paint thinners, and paints, should be stored in well-ventilated exterior locations, not inside the building. If this is not feasible, then such products and substances should be stored in a place that is sealed to the living area. In all cases, they should be stored in airtight containers. Old paint, banned pesticides, and other products that will not be used should be disposed of properly. Most local jurisdictions have household hazardous waste disposal locations.

Figure 5.19 Principles to Keeping It Contaminant-Free

- Safely address lead-based paint hazards.
- Be aware of volatile organic compounds when making purchases.
- Control occupational take-home hazards.

Radon Control

An EPA review of radon mitigation studies concluded that 97 percent of houses with high baseline radon level (76 percent had baseline radon level ≥ 10 picoCuries per liter (pCi/L) could be remediated with active soil depressurization systems to less than 4 pCi/L.⁶⁷ A national survey showed that 95 percent of remediated homes had < 4 pCi/L, and 69 percent actually had < 2 pCi/L ($n=238$ houses) levels.⁶⁸ The durability of these active systems has been assessed in relatively small studies, with the exception of one that showed 95 percent of houses had < 4 pCi/L levels 18 months after installation.⁶⁹ Another found that 11 of 13 houses evaluated had levels below 4 pCi/L two years after installation.⁷⁰

A qualified or licensed contractor is necessary to guarantee proper installation of the various radon mitigation systems. Many national and local green building standards now include radon-resistant elements.

Passive radon mitigation. Passive radon mitigation techniques are used most often in new construction. A passive system is comprised of a pipe that runs from beneath the foundation slab up thorough the house (usually in a wall void) to above the roof where the radon gas vents. This system may not be effective in consistently reducing indoor radon level to less than 4 pCi/L. These systems are described in greater detail by EPA in Radon Reduction Techniques for Existing Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization Systems.⁷¹ While sealing cracks and other openings in the foundation reduces the loss of conditioned air and makes other radon reduction techniques more effective and cost-efficient, sealing has not been shown to lower radon levels significantly or consistently by itself.

Radon-resistant new construction measures should always be implemented in EPA Zones 1 and 2 as indicated on its radon map. The techniques involve the use of gas impermeable membranes at the foundation and sealing of all penetrations. Chapter 5 of the HUD/CDC Healthy Homes Reference Manual describes the installation process in detail. For new construction, details are available at: www.epa.gov/radon/rrnc/index.html.

In some instances, sealing crawl spaces, which has other benefits, increases radon levels in the home; thus, radon testing should always be done in concert with crawl space sealing. Further details are at: www.epa.gov/radon/index.html.

Active radon soil depressurization. Active soil depressurization is in most applications the most effective radon mitigation technique. It can be used in mitigating radon exposure in existing homes and installed as a system in new homes at the time of construction. It is comprised of a vent pipe with a fan in it that runs from beneath the foundation slab up (either outside or inside the home) to above the roof where the radon gas is vented. EPA's current recommended standard of practice for these systems is ASTM E 2121. Merely sealing the basement is usually inadequate due to the stack effect and also because most buildings are under negative pressure with respect to the exterior. The stack effect means that air rises from lower to higher levels in most buildings.

Particulate Matter

Inhalable particles, which can trigger asthma, can be controlled by use of efficient filters in air handlers, use of High-Efficiency Particulate Air Filter (HEPA) vacuum cleaners, elimination of "dust sinks" like older soiled carpets, adoption of smoke-free housing policies, and regular cleaning. Central vacuum cleaners, if available, are another way of reducing exposures. Although studies to date provide insufficient evidence of effectiveness, portable air cleaning devices are available for use. They have been used as part of multi-component interventions to improve asthma control for children and are appropriate to control small particles that stay suspended in the air (e.g., environmental tobacco smoke, mold spores, pet allergens). However they are not appropriate for control of larger particles such as the allergens associated with cockroaches and dust mites. Devices that produce ozone, however, should be avoided. (See ventilation section for more details on filtration of indoor air.)

Secondhand Smoke

Also known as environmental tobacco smoke (ETS), secondhand smoke is a major issue in both single- and multi-family housing. A number

of studies in non-residential settings have demonstrated the effectiveness of smoking bans in improving health and reducing exposure to ETS.^{72, 73, 74, 75} Because ETS can migrate between apartments, smoking bans are particularly relevant for multifamily buildings. Research has shown that children living in multifamily housing have greater exposure to ETS, regardless of whether or not there is a smoker in the immediate household.⁷⁶ Many green building programs now include bans on smoking (e.g., Enterprise, LEED).⁷⁷ The cost of cleaning and maintaining units in which smoking has occurred is substantially greater than for non-smoking units. Adopting smoke-free policies is an effective intervention and described in detail in the “Keep It Clean” section below.

More and more landlords, property management companies and condominium associations are making properties completely smoke-free. Many take this step because they value the health of their residents; many want to reduce fire risk; and many are responding to the demand for smoke-free living. Just like prohibiting pets, landlords and associations can prohibit smoking. It is entirely legal. Simply write into your lease, “No Smoking anywhere on the property, including inside any apartment.” Refer to Boston Smoke Free Homes for model lease language (bostonSmokeFreeHomes.org). Having smoking cessation assistance available to residents will increase the chances of success.

Occupational Take-Home Health Hazards

Healthy homes programs should include information on how exposures to toxic substances on the job can be inadvertently transferred to the home environment on clothing (especially shoes) and in family automobiles. Some OSHA standards, such as the one on lead, provide requirements for decontamination before leaving worksites. Decontamination measures include:

- Removing work shoes and or clothes if necessary before entering the family automobile or home.
- Shower immediately after arriving home
- Laundering work clothes separately from the family laundry.

Contact one of the following for more information on occupational health and take-home hazards: Occupational Safety and Health Administration: <http://osha.gov/workers.html> or the Center to Protect Workers’ Rights: <http://www.cpwr.com/about-overview.html>.

Principle #6: Keep It Clean

Proper cleaning and maintenance, including preventive maintenance, represent two important and related healthy housing principles. Cleaning is typically the occupant’s responsibility (except for common areas in multifamily housing) although there are exceptions to this general rule such as cleaning at unit turnover. Maintenance is typically the owner’s responsibility. Information on cleaning education and controlling asthma triggers are discussed in the resident education section at the end of this chapter. Cleaning to control asthma triggers should be consistent with recommendations of the National Guidelines for the Diagnosis and Management of Asthma Expert Panel Report 3 (2007): <http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.htm>.

Review of the Evidence

Cleaning and maintenance alone are usually not sufficient to create healthy housing because sources of hazards must also be addressed. For example, Tohn et al., (2003)⁷⁸ showed that even repeated professional cleanings alone do not prevent childhood exposure to lead-contaminated dust. It is important to note, however, that cleaning is often appropriate as an immediate, short-term fix for many housing-related health hazards and as a component of multi-faceted interventions.

Figure 5.20 Principles for Keeping It Clean

- Assure smooth and cleanable surfaces.
- Reduce exposure to environmental tobacco smoke.
- Use low toxicity cleaning supplies only as directed.

Structural Interventions

Cleanable surfaces

Difficult-to-clean surfaces, although not hazards in and of themselves, may facilitate a host of problems. For example, if food preparation surfaces are not smooth, they cannot be adequately cleaned to prevent food-borne communicable diseases. Food particles can also become available to pests. Difficult-to-clean surfaces on floors and window sills may also make the re-accumulation of lead-contaminated dust and subsequent exposure more likely.

Carpets

Carpets are not appropriate for wet areas, such as kitchens, baths and laundry rooms because they are more difficult to dry and keep clean. Carpets in other rooms can also act as dust reservoirs if not routinely cleaned. Carpet removal and substitute materials have been the subject of numerous studies, with mixed evidence as a means to reduce airborne dust levels or biological and chemical contaminants in settled dust (NCHH July 2008 Fact Sheet).⁷⁹ If your program chooses to replace carpet, consider the following practices:

- If you choose to install new carpet, check whether the product has the Green Label Plus designation from the Carpet and Rug Institute, an organization that sets product standards for indoor air quality and identifies those with very low VOC emissions. Also, low pile

carpeting is easier to clean than higher pile carpeting.

- Use low-VOC adhesives when installing wood underlayment and padding.

Heating, ventilation, and air conditioning systems

Inadequate cleaning of these systems can lead to mold from blocked coils and higher fuel bills due to energy inefficiency. Condensate drains should be kept clear. Furnace filters should be changed when they become overly loaded in order to permit proper air movement throughout the dwelling and adequate removal of particles. Cooling coils should also be kept clean (Figure 5.22).

There is little evidence to support the need for routine cleaning of ductwork because particulate matter settles inside the ducts and is likely to stay, barring physical disturbance of the ducts. Therefore, duct cleaning is often unnecessary and, if performed, may produce more hazards.⁸⁰ Extensive wetting of ducts and mold infestation are exceptions. In this situation, ductwork should be cleaned and the source of moisture removed and in some cases the duct work may need to be replaced. Depending on the size of the mold infestation, duct cleaning may require mold professionals and ventilation specialists. Bare metal ductwork can be cleaned, but for fiberglass duct board, flexible ducts, and metal ducts with interior liners, the efficacy of cleaning is questionable and are typically replaced when contaminated.

Figure 5.21 Carpets

The following green building guidelines recommend against wall-to-wall carpet in certain areas:

- Enterprise Community Partners' Green Communities Criteria: Requires the use of materials that have smooth, durable, cleanable surfaces in wet areas.
- U.S. Environmental Protection Agency Energy Star with Indoor Air Package: Prohibits wall-to-wall carpet adjacent to toilets and bathing fixtures (i.e., tubs and showers).
- National Association of Home Builders Green Builder Guidelines: Prohibits carpets in bathrooms.
- U.S. Green Building Council's LEED for Homes: Requires water-resistant flooring in kitchens, baths, and spa areas and within 3 feet of exterior doors

Source: NCHH, 2008 Fact Sheet: Carpets and Healthy Homes

Figure 5.22 Dirty Cooling Coils Should Be Cleaned



Asbestos may be present in pipe and boiler insulation and other building insulation systems. Cleaning operations should not disturb such insulation. If it deteriorates or is disturbed, cleaning should be performed by a licensed asbestos contractor.

Adopting a Smoke-Free Rental Policy

Public housing authorities and others have begun to adopt smoke-free rental policies, not only because of health benefits but also because it reduces costs of cleaning, repairs, and component replacement at unit turnover (Figure 5.23).

Low-Toxicity Cleaners and Safe Use and Storage of Supplies and Equipment

Some cleaning agents carry their own health and safety hazards. Bleach and ammonia compounds are common cleaning products that can cause severe eye and skin injuries if not handled properly. If mixed, they release dangerous gases (such as phosgene and other gases) that can cause severe respiratory injury and even death. If the instructions call for dilution, then use of the undiluted product may cause high exposures as well as damage to building structures. Products (such as bleach and ammonia) should never be mixed and instructions on the product label must be followed. Proper eyewear and skin protection should also be worn if exposures are likely. If eye contact with cleaning agents does occur, then a full 15-minute immediate rinsing of the eyes is critical. Avoidable eye injuries have occurred because injured persons attempted to seek medical attention instead of performing

Figure 5.23 Smoking and Non-Smoking Housing Costs

Boston One Touch: Action Steps for Healthier and Greener Homes for Boston Families reported sizeable cost differences in smoking and non-smoking units.⁸¹

The Financial Burden		
Non-Smoking Unit		
Labor	12 hours X \$35/hour	\$420
Paint	3 Gallons	\$60
Ceiling Paint	2 Gallons	\$40
Carpet Shampoo		\$50
TOTAL		\$570

Smoking Unit		
Labor	30 hours X \$35/hour	\$1,050
Paint	4 Gallons	\$80
Ceiling Paint	3 Gallons	\$60
Carpet Shampoo		\$50
Primer		\$100
Replace Rug Burns*		\$600
Replace Laminates*		\$800
TOTAL		\$1,340 - \$2,740

*Costs depend on carpet and countertop condition

Analysis provided by Sanford Housing Authority, 2004, and Auburn Housing Authority, 2006. Courtesy Smoke-Free Housing Coalition of Maine

the rinsing, resulting in permanent damage to the eyes on the way to the hospital.

New “non-toxic” cleaning products are appearing on the market, some carrying “green” or “natural” labeling. While intuitively appealing, such products may not, in fact, be any safer than others. Therefore, healthy homes programs should instruct occupants to read product labels closely to ensure proper use of all cleaning products. While voluntary labeling programs exist, there are no national standards that enable consumers to make truly informed choices.

Cleaning Guidelines

- Use low toxicity products.
- Use cleaning products only according to the label instructions.
- Use appropriate eye and skin protection when using cleaning products.

All carpets should be vacuumed periodically. Normal household vacuum cleaners can emit fine particulates through the exhaust, which can lead to increased levels of airborne particulate matter. Use of High-Efficiency Particulate Air (HEPA) vacuum cleaners is one solution. HEPA vacuums are equipped with special filters to remove nearly all of the small particles from

the vacuum exhaust that would otherwise re-enter the room air, and are now widely available and affordable. Some healthy homes programs offer a HEPA vacuum rental or loan services. All vacuums used on carpeted floors should be equipped with a beater bar to dislodge bound particulate matter. Conventional vacuums with micro-filtration bags may also be effective.⁸² Vacuum cleaner reviews and rating are available from Consumer Reports at www.consumerreports.org/.

Another option is to install a central vacuum system, which filters the indoor air and deposits the exhaust air outside the house. Central vacuum systems are increasingly used in new construction; retrofits into existing housing may be quite expensive.

All cleaning agents, as well as other products containing poisons, irritants, or VOCs should be stored in locked areas that children cannot access.

Portable Air Cleaners

The ability of portable room air cleaners to remove particulate matter of certain size ranges from air is well established (Figure 5.24). Specifically, air cleaners are known to be able to achieve a 30–70 percent reduction in the half-life of airborne particulate matter between 0.3 to 1 microns.⁸³ However, portable air cleaners do not reduce larger airborne particles between 1 to 5 microns because they deposit at rates that are much higher than the equivalent loss rate due to typical residential ventilation. Air cleaners are less effective as the particle size increases and they have not been demonstrated to reduce volatile organic compounds or other gases such as carbon

monoxide, oxides of nitrogen and others.⁸⁴ It is also unlikely that these systems can adequately control exposures to environmental tobacco smoke; source control through smoking cessation will be far more effective. This has led the National Academy of Sciences to conclude that there is only limited evidence that air cleaners are effective in reducing asthma.⁸⁵ This is most likely because allergens may be concentrated in the larger particle size ranges. EPA provides information on air cleaner technology for the home environment at: <http://www.epa.gov/iaq/pubs/airclean.html>.

Some air cleaners emit high levels of ozone under the theory that this reactive gas will clean the air. Exposures to ozone should always be avoided because it is a strong lung irritant and has many adverse health effects. These devices should not be used in the home environment. Occupants should be encouraged to avoid using ozone generating air cleaners. EPA provides additional information on ozone generators sold as “air cleaners” at <http://www.epa.gov/iaq/pubs/ozonegen.html>.

Principle #7: Keep It Maintained

Structural Interventions

The previous sections of this chapter have described conditions that require correction to create a healthy home. However, simply correcting the deficiencies will not have a long-term impact unless a regular maintenance program is implemented so that new deficiencies are promptly addressed (Figure 5.26). Regular

Figure 5.24 Portable Air Cleaner



Figure 5.25 Principles for Keeping It Maintained

- Conduct preventive maintenance and regular inspections.
- Respond to maintenance concerns in a timely manner.
- Keep dust levels low through regular cleaning.
- Address hoarding behavior.

inspections are part of maintenance.

For example, if existing leaks only in the roof are repaired without implementing a system that identifies roof conditions before leaks occur, mold damage can take place before it is discovered. Similarly, if enclosures that prevent exposure to lead-based paint fall into disrepair, lead paint that previously did not present a hazard because there was no exposure could become a hazard. Condensate drainage systems that are not kept clean can fail to drain properly, leading to mold and moisture problems. Radon mitigation systems can fail if not monitored.

Some building systems become so aged and deteriorated that proper maintenance is no longer feasible or financially viable. Healthy homes programs refer these homes to Community Development Block Grant (CDBG) housing rehabilitation programs for capital improvements or building code enforcement for condemnation and/or demolition.

Maintenance and cleaning operations apply to both the interior of the home and the site. Vegetation should be trimmed and maintained to avoid moisture and mildew problems or water ponding on the grounds. Furnace filters should be changed regularly.

Routine Maintenance Schedule

A simple checklist for owner-occupied single-family housing has been developed by the National Center for Healthy Housing (Appendix 5.2). For multifamily large apartment complexes, schedules with more frequent inspections may be necessary, depending on the complexity

and operation of the building systems. The sample checklist is not exhaustive but is a good indication of key items that should be examined on a regular, ongoing basis.

Cleaning for the Control of House Dust Containing Lead

There are numerous resources on how to clean effectively to control lead dust after disturbing lead-based paint. Contractors and maintenance staff should take a formal lead-safe work practices course and the EPA-certified renovator training. EPA now regulates many renovation, repair and painting activities. Occupants can use many of these same practices to continue to keep dust levels low after renovation. Key lead-safe work practices include:

- Clean from ceiling to floor.
- Vacuum all surfaces first with a HEPA vacuum, then wet wash using separate containers for soapy water and clean rinse water, and repeat vacuuming.
- Use cleanable floor mats in the entryway and remove shoes before entering the living space to avoid track-in of lead-contaminated soil.
- Wash hands and face before eating, drinking, smoking, or applying skin lotions if in contact with lead-contaminated dust or soil.
- Wash clothes that may have been in contact with lead-contaminated dust or soil separately from the rest of the household's laundry.

The New England Lead Coordinating Committee's Don't Spread Lead video provides a simple review of these practices, as well as lead-safe work practices for "do-it-yourselfers." Detailed information on lead hazard control is discussed in the cleaning section above.

This lead-contaminated dust cleaning protocol can also reduce exposure to other contaminants in dust.

Hoarding

Healthy homes practitioners should be aware that some occupants may suffer from the compulsion to hoard, resulting in clutter. Hoarding increases risk of pest infestations,

Figure 5.26 Maintenance

Maintenance is a key component of a healthy home. Key educational messages include the following:

- Maintenance needs should be addressed promptly.
- A regular schedule for maintenance can be adopted to help ensure deferred maintenance does not lead to major repairs later.

injuries, and other problems. In some cases, this may require a referral to professionals for mental health services.

Hoarding situations must be handled in a multidisciplinary manner. Healthy homes programs should address hoarding as part of a team that may include the sufferer, family members, the housing provider, local health departments, representatives of the judicial system, and providers of therapeutic, social and clean-up services. Long-term case management and monitoring is needed.

Energy Efficiency

Healthy homes programs should build ties with local programs that weatherize or otherwise improve energy efficiency. Installed and used correctly, there is evidence that energy-efficient measures indirectly improve respiratory health^{86, 87, 88} by reducing drafts, increasing thermal

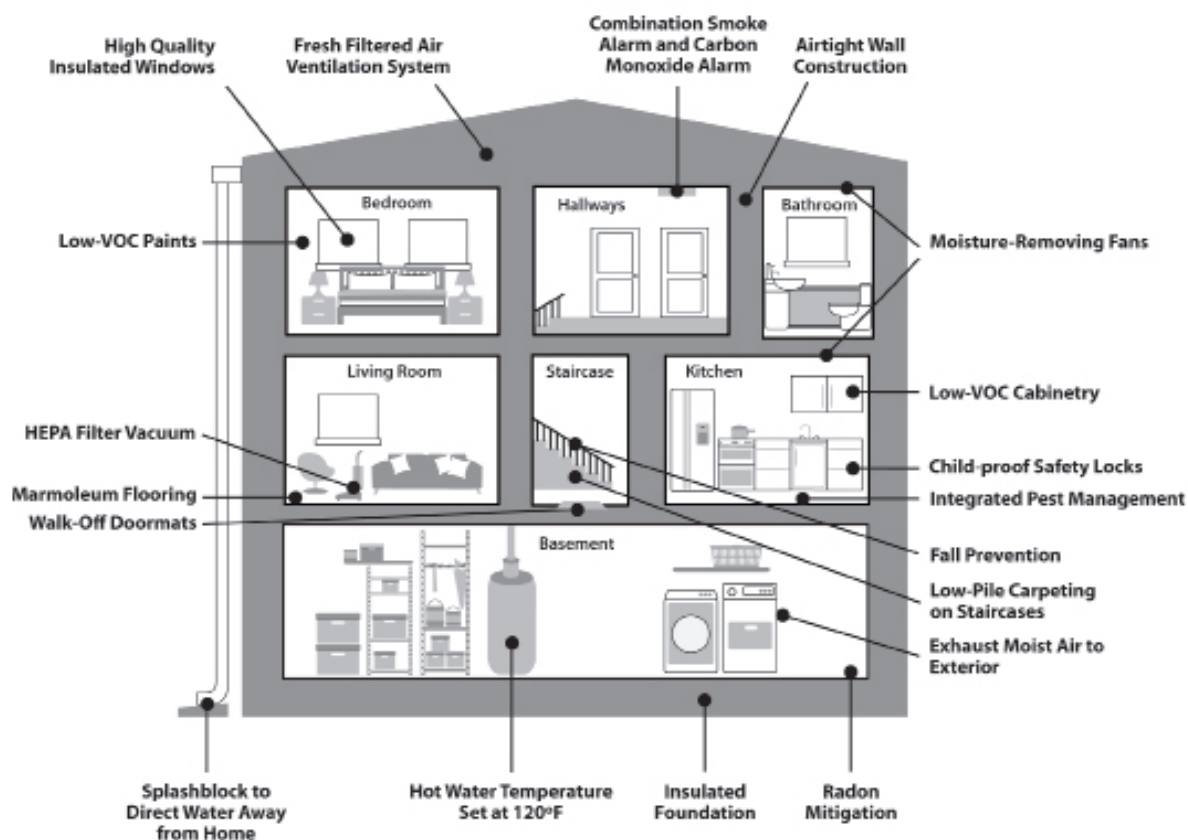
comfort and controlling excess moisture and mold. There is also evidence that sealing building envelopes below prescribed building tightness limits can necessitate adding additional fresh air supply to prevent the creation of other health hazards, such as mold.

A Seattle-based Healthy Homes project⁸⁹ incorporated a variety of green, healthy homes and energy efficiency measures that produced significant health improvements for asthmatic children. The diagram below shows some of the interventions, including fresh filtered air ventilation, high-efficiency windows, and a heat recovery system (Figure 5.27).

Improving energy efficiency can also significantly increase household disposable income for low income families, which can improve health through better nutrition and diet.

Security

Figure 5.27 Healthy Housing Interventions Used In New Construction at Seattle's High Point "Breathe Easy" Homes



Inadequate security can increase stress, which in turn has been associated with encouraging or worsening asthma. Broken windows, non-operational locks, and inadequate lighting have all been associated with adverse health outcomes. Crime and fear have also been associated with adverse health outcomes. Healthy homes programs should determine if program clients are concerned about security issues and, if so, tailor interventions to improve their sense of security.

Resident Knowledge and Education

Introduction

Residents in housing units served by healthy homes programs can be either tenants or owner occupants. In rental property, it is crucial that tenants and property owners and maintenance staff work together to assure a healthy living environment. Program considerations for healthy homes interventions aimed at resident education and behavior change are delineated in Figure 5.28.

Video instructional tools can also be very useful for tenant education. Examples of short,

practical videos for tenant education in English and Spanish can be found at: <http://www.healthyhomestraining.org/ipm/videos.htm>.

Keep it Dry

Resident behavior has a significant impact on moisture levels in a home. For example, failure to turn on kitchen and bathroom fans during cooking and bathing, respectively, can raise moisture levels significantly. Elimination of cardboard boxes and other cellulose building materials in areas prone to high moisture levels helps to control mold and moisture problems.

Tenants should promptly report leaks, condensation and other moisture problems to the property owner. Education programs should address how to use exhaust ventilation to remove moisture while showering and cooking. Tenants should also be taught how to use and maintain equipment properly such as humidifiers, dehumidifiers, and drains.

Keep it Ventilated

Use of supplemental unvented heating equipment, such as kerosene heaters, should be discouraged because they can produce high levels of carbon monoxide and other combustion gasses. Also, residents should be taught how to assess that kitchen and bathroom exhaust fans are vented to the outside and are working properly. A simple test is to hold toilet or tissue paper over a bathroom fan intake vent. If the paper is not kept aloft by the fan, there is insufficient exhaust. Also, since many low-income families worry that running fans will increase electricity bills, they should be provided with information on the average monthly cost to run this equipment compared to home repair and health costs that can result from non-use. Families can also be prompted to watch for signs of excess humidity, such as water condensing on windows and bathroom mirrors taking a long time to clear after showering.

Keep it Pest-Free

It is important that tenants understand the life cycle of pests common to their region and begin pest control as soon as the problem is first observed. Although a new problem may

Figure 5.28 Behavioral Change

Programs that demonstrate the most significant and permanent behavioral change also:

- Engage Community Health Workers from the same cultural or socioeconomic background to deliver the training.
- Conduct multiple home visits to build trust, deliver education at “teachable moments,” and engage family members in demonstration and return demonstration of specific practices.
- Provide resources residents may need to accomplish the behavioral change. Many programs provide cleaning supplies referred to as “cleaning buckets,” or “home cleaning kits,” as an incentive for participation and to support behavior change.
- Provide education on the seven healthy homes principles.

appear trivial, it may be far more serious than it seems. Pests such as cockroaches colonize in large groups behind walls; others, such as rats, prefer to live outside but enter buildings to find food and water. Pests can be a health hazard. For example, cockroach and mouse allergens are important asthma triggers. Critical educational messages include:

- Promptly clean up food and drink spills.
- Remove clutter (such as cardboard boxes or paper) so pests have fewer places to hide.
- Put food in tightly sealed containers. Do not leave open containers of food on counters or in cabinets. Put pet food dishes away overnight.
- Keep trash in a closed container and take it out frequently, every day if possible. Do not let trash pile up inside or outside.
- Use roach baits properly and only when necessary. Place baits out of the reach of children and pets.
- Put baits close to the pests' hiding places. Baits must be closer than other sources of food.
- Good spots for baits are next to walls, baseboards, under sinks, in cabinets and near plumbing fixtures. Place baits in areas of roach activity.
- Do not spray pesticides, as it will keep the pests away from the baits.

Keep it Safe

The Home Safety Council's checklist can be used as part of your education strategy to help occupants find and fix hazards in their homes. While not all-inclusive, it is helpful (http://www.homesafetycouncil.org/SafetyGuide/sg_safetyguide_w001.asp).

Keep it Contaminant-Free

There are numerous ways residents can reduce or prevent exposure to contaminants such as lead dust and environmental tobacco smoke. They should be instructed to report chipping or peeling paint promptly to their property

owner so that it can be safely repaired. Products containing VOCs should be limited to minimize exposures. Vacuuming should be conducted regularly to keep dust levels low. Exposure to secondhand smoke can be minimized by smoking outside of the housing unit.

Keep it Clean

"Cleanliness" is a concept with powerful cultural and emotional connotations. Few individuals want to hear they do not live in a "clean" house, even when evidence of clutter, mold, or pests is obvious. Moreover, many low-income families lack the resources for cleaning supplies readily available to higher income families. Others may feel that the source of their problem is out of their control, such as failure of owners and property maintenance staff to address holes, leaks, and pests. As a result, tenants can give up. They lose the motivation to undertake action that would protect their health without clear support and engagement of rental property owners and managers in the process.

Low toxicity cleaning supplies should be used whenever possible. Reducing clutter and storing food and trash in pest-proof containers are important aspects of integrated pest management. Regular cleaning and mopping of horizontal surfaces—counters, tables and floors—and vacuuming should be conducted to reduce dust levels, pet dander and food sources for pests.

Regular washing of bedding in hot water is effective in reducing dust mites. If pets are present, controlling dander is also helpful, especially for those with asthma. Pets can also be kept out of the bedrooms to help minimize exposures. Extensive clutter can promote pest infestation and result in injuries, such as trips and falls and should be eliminated.

Keep it Maintained

Resident knowledge of maintenance practices should be a key focus of healthy homes programs in support of physical interventions. Tenants need to report maintenance needs to rental property owners promptly and with confidence their requests will be respected and addressed. Furnace filters should be checked each time the

season changes and replaced as needed.

Special Focus on Asthma

Residents need to recognize and address conditions that trigger allergic or asthmatic reactions (Figure 5.29). Responses call for a multi-faceted, comprehensive approach focused on those allergens/irritants to which the person with asthma is sensitive. Common measures include:

- Regularly washing bedding and toys kept in the bed in hot water (120° F) to control dust mites, as well as using breathable mite-proof mattress and pillow covers. Other furniture used as beds, such as sofas, should be kept clean.
- Damp-dusting or mopping floors and horizontal surfaces.
- Slow and careful vacuuming, preferably with vacuums equipped with dirt sensors and bags to trap collected dust and debris. HEPA vacuums should be used if feasible to control emission of particles from vacuum exhaust.
- Controlling exposure to pet dander by restricting pets' access to sleeping areas.
- Avoiding secondhand tobacco smoke.
- Controlling mold and moisture.
- Minimizing carpet and dust-collecting items in the bedrooms of asthmatics.
- Storing food in pest-proof containers and trash in containers with secure lids.



- Reducing clutter in order to prevent conditions where pests can live and breed.
- Dry steam cleaning of upholstered furniture to kill and remove dust mites.

Figure 5.29 Asthma Education Issues

- Identification and control of asthma triggers such as pet dander control, dust mite control, actions to reduce colonization by mold or pests.
- Use of non-toxic cleaning products and product storage.
- Use of allergen-proof covers to encase mattress and pillows in. Weekly washing of sheets and blankets in hot water.
- Reducing indoor humidity to less than 60 percent, ideally between 30–50 percent.
- Minimizing the number and weekly washing of stuffed toys.
- Reducing cockroach and rodent allergen exposure with an integrated pest management approach including a combination of blocking access, low toxicity pesticides, traps, and vacuuming and cleaning.
- Controlling pet allergen by (ideally) removing the pet from the home or barring it from the bedroom and keeping it off upholstered furniture and carpets.
- Taking such mold and moisture control measures as:
 - ▶ Fixing leaks and other sources of moisture that support mold growth.
 - ▶ Cleaning moldy surfaces with soap and water and drying thoroughly.
 - ▶ Discarding and replacing items that can not be cleaned and dried effectively.
 - ▶ Do not use the oven to heat the home and, if available, use the stove vent when cooking.
- Instituting a smoke-free home policy.

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