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Carpets and Healthy Homes

The impact of carpeting in home environments on health and safety is an active area of scientific research. The current evidence shows that some aspects of carpets can benefit the health and safety of occupants, while other aspects can contribute to illness and injury. Based on the currently available data and professional judgment, the National Center for Healthy Housing offers the following recommendations regarding maintaining, cleaning, and replacing carpets to promote a healthy home environment:

Recommendations:

1) Avoid Wall-to-wall Carpets in Damp Areas and in Rooms of Individuals with Allergies or Asthma.

- **Avoid installing wall-to-wall carpeting in bathrooms, kitchens, laundry rooms, basements, or other damp areas.** Choose area rugs in these rooms instead and wash them frequently, or use hard flooring with non-skid features. Choose water-resistant floors in basements, below-grade rooms or slab-on-grade construction, where moisture is a potential problem.
- **Consider not installing wall-to-wall carpeting in a bedroom for a person who has asthma or allergies, especially a person who is sensitive to pet dander and dust mites.** It is better for people with allergies (particularly those with dust mite allergies) to avoid wall-to-wall carpeting, especially in bedrooms, because hard-surface floors are easier to clean than carpet. Flakes of human skin are the main food for dust mites. Although dust mites can be removed by regular vacuuming, they will accumulate without thorough and frequent cleaning. Once established, dust mites are difficult to remove from carpeting. Small area rugs can be helpful, but need to be cleaned regularly and should have non-slip backings to avoid becoming a trip hazard. There is emerging evidence that some hard flooring (such as vinyl flooring) containing phthalates (a type of plasticizer) may also contribute to asthma,¹ and should either be avoided from a precautionary stand-point or cleaned regularly with a damp mop to reduce dust. For those with asthma, discuss flooring options with your physician as part of your asthma management program.

¹ Mendell M.J. "Indoor residential chemical emissions as risk factors for respiratory and allergic effects in children: a review." *Indoor Air*. 2007; 17: 259-277.

2) Select Less Toxic Materials and Installation Practices.

- **If you have wall-to-wall carpeting in bathrooms, kitchens, and damp rooms, consider replacing it with a smooth, non-absorbent, non-skid surface at your next opportunity.** Hard floors (like all floors) need to be cleaned regularly. Examples of hard floors include but are not limited to wood, ceramic, linoleum, rubber, marmoleum (a natural floor covering manufactured with linseed oil, wood flour, resin, jute, and finely crushed limestone and mineral pigments), and wood laminate.
- **If you install wall-to-wall carpeting, allow the carpeting to thoroughly air out before using the area; buying carpeting that has a Green Label from the Carpet Research Institute may also help.** These methods may reduce exposures to individual volatile organic compounds used in the carpet or adhesive, which may be either directly related to occupant health, or which may react with other substances to produce harmful exposures.

3) Maintain Carpets with Good Quality Vacuums, Preferably a HEPA Vacuum.

- **If you have carpeting, purchase a quality vacuum that has a High Efficiency Particulate Air (HEPA) filter or high efficiency filter and use it weekly or at least every other week.** Multiple passes with the vacuum are recommended. One minute per square yard of carpet is a good starting point. More time may be needed for very dirty carpet, shag carpet, or those with thick pile. In selecting a vacuum, price is not always a good indicator of quality. Go to *Consumer Reports* at www.consumersunion.org to research your options. Vacuums with a beater bar help loosen and remove particles that are held in the carpet. HEPA vacuums have special filters that reduce dust emissions from the vacuum exhaust. They must also have a motor powerful enough to make up for the added resistance of the HEPA filter (some HEPA vacuums do not).
- **If you steam clean carpet, be sure to dry it thoroughly.** Steam cleaning may leave moisture behind that could attract pests and could lead to mold in the carpet or carpet padding. When steam cleaning or shampooing carpeting, use fans to dry it out, and open windows if it is a low-humidity day. On a high-humidity day, run an air conditioner or a dehumidifier. If using “spot cleaners,” follow label directions. These products are not intended for entire carpet coverage.
- **If carpeting is worn or heavily soiled, replace it.** Carpet that is loose or has tears, folds, or bumps is a trip hazard and may result in a fall. Make sure you know what’s under the carpet before removal. The floor beneath may be in poor condition, or a finished floor may not even be present. Care must be taken when removing carpets from homes built before 1978 to ensure that lead dust in or under the rug does not become accessible to occupants. Clean walls and horizontal surfaces thoroughly after replacing wall-to-wall carpeting to remove any contaminants released from the carpeting and padding. If you install new carpet, consider using low pile carpeting, which is easier to clean than high-pile carpeting.
- **Clean second-hand area rugs before using them.** These rugs may have lead dust and other contaminants in them from previous uses.
- **If you are a renter or are planning to rent, compare the property to these recommendations and talk with the property owner or manager if you have concerns.**

Research Review:

In the past fifty years, carpeting has moved from a luxury item to commonplace. Carpets and rugs account for 65% of the floor covering market, although hard surface flooring, especially laminates, ceramic tile, and wood, are becoming increasingly popular. See [www.carpet-rug/pdf word docs/fact sheets/IAQ Consumers.pdf](http://www.carpet-rug/pdf_word_docs/fact_sheets/IAQ_Consumers.pdf). This

market transformation has affected both new and old homes. In a national survey, the U.S. Department of Housing and Urban Development (HUD) found that 92% of homes had a carpet or rug in at least one of the four rooms sampled.² The U.S. Environmental Protection Agency (EPA) estimates that approximately 54 million housing units built prior to 1978 contain some wall-to-wall carpeting,³ which is about 66% of homes. Some property managers require carpeting on as much as 80% of the floor areas to reduce noise.⁴

Limiting Wall-to-wall Carpet

It is estimated that about 40% of the population has been sensitized to allergens.⁵ According to the National Academy of Sciences, "The magnitude of the potential significance of carpeting as a source and reservoir of indoor allergens indicates that it should be given consideration as a serious problem."⁶ Carpets accumulate dust and dirt in the amount of approximately 5-25 grams per square meter of surface area, depending on type of material, foot traffic, and other factors,⁷ which is a far greater extent than hard flooring. People stir up a personal cloud of dust not visible to the naked eye through normal indoor activities (such as walking and cleaning), resulting in increased personal exposures to whatever is in the dust.^{8, 9, 10} One nationwide study showed an association between asthma severity and the total dust weight on floors, and showed that carpets had higher total dust weights than hard floors.¹¹ Further research is underway to elucidate precisely how exposures to particulates in carpet occur. New varieties of carpeted floor coverings are needed that accumulate less dust and dirt during usage and are easier to clean.

Standards and Guidelines - Several local housing codes prohibit wall-to-wall carpet in bathrooms by requiring a smooth, hard, non-absorbent surface.¹² The goal is to have a clean and cleanable surface to promote sanitary conditions. However, the 2006 versions of the International Residential Code and the International Property Maintenance Code do not prohibit carpets on bathroom floors.^{13, 14}

² U.S. Department of Housing and Urban Development. Clickner R., Marker D., Viet S.M., Rogers D., and Broene P. *National Survey of Lead and Allergens in Housing: Final Report, Vol. 1: Analysis of Lead Hazards*. Office of Lead Hazard Control, U.S. Dept of Housing and Urban Development, Washington, D.C. 2001.

³ U.S. Environmental Protection Agency, "Lead; Renovation, Repair and Painting Program; Proposed Rule." January 10, 2006 *Federal Register*, Vol. 71, pp. 1587-1636, Docket #EPA-HQ-OPPT-2005-0049-0001. See page 1615.

⁴ Montgomery County, Maryland. *Landlord-Tenant Handbook*, p. 48. See www.montgomerycountymd.gov/content/dhca/images/PDF/handbook_web.pdf.

⁵ Roberts J.W., Dickey P. "Exposure of children to pollutants in house dust and indoor air." *Rev Environ Contam Toxicol*. 1995;143:59-78.

⁶ National Academy of Sciences/Institute of Medicine. 1993. *Indoor Allergens: Assessing and Controlling Adverse Health Effects*. Pope AM, et al. (eds), National Academy Press, Washington, D.C.

⁷ Morey P. Personal communication.

⁸ Ferro A.R., et al. "Source Strengths for Indoor Human Activities That Re-suspend Particulate Matter." *Environmental Sci. Tech.*, 38:1759-1764, 2004.

⁹ Ferro A.R., et al. "Elevated personal exposure to particulate matter from human activities in a residence." *J Exposure Analysis and Epidemiology* (14) S34-S40. 2004.

¹⁰ Canadian Mortgage and Housing Corporation. *Indoor Particulate and Floor Cleaning. Research Highlight*. Technical Series 03-104. May 2003. Available: <http://www.cmhc-schl.gc.ca/odpub/pdf/63186.pdf>.

¹¹ Arbes S, et al. "Dust Weight and Asthma Prevalence in the National Survey of Lead and Allergens in Housing (NSLAH)." *Environmental Health Perspectives* v.115 (2); Feb 2007.

¹² See National Healthy Homes Training Center and Network summary of housing codes at www.healthyhometraining.org/Codes/index.htm.

¹³ International Code Council, 2006 *International Residential Code*, Section 307.2, and the 2006 *International Property Maintenance Code*, Section 503.4. *The International Residential Code requires a smooth, hard, nonabsorbent surface only for the bathtub and shower. The International Property Maintenance Code requires it for toilet rooms but excludes dwelling units.*

¹⁴ See www.centerforhealthyhousing.org/html/amendments_to_ipmc.htm.

Green building standards generally discourage wall-to-wall carpeting in damp areas. According to NCHH's analysis of national green building program guidelines,¹⁵ 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 Pilot Specifications: 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.

Potential Benefits of Carpeting on Dust Control - A few research studies have shown that *airborne* dust levels can actually be lower in carpeted rooms as compared to non-carpeted rooms. This unusual finding has been observed in situations where the carpet has been maintained with an aggressive vacuuming schedule. One such study compared airborne dust levels in classrooms and found lower levels in carpeted rooms even after heavy foot traffic, which would be expected to transfer particulates from carpet into air.¹⁶ This reduction may be due to the "sink" capacity of carpets to hold particulates as they settle from the air, and depends on a program of regular carpet maintenance.¹⁷

Other studies show that biological and chemical contaminants in settled dust were lower on carpeted floors than bare floors. A recent pooled analysis found that when bedroom floors were at least 50% carpeted, cockroach allergen concentrations were lower than when floors were less than 50% carpeted.¹⁸ The U.S. Department of Housing and Urban Development (HUD) found that dust lead levels measured using the standard surface wipe method were 25% lower on carpeted floors than smooth-cleanable hard floors and 75% lower than uncarpeted floors that were not easy to clean (e.g., pitted or damaged),² although it is noteworthy that lead wipe samples from carpets were still significantly correlated with children's blood lead level.¹⁹

One small intervention study (N=10) showed that steam cleaning of carpeted floors was more effective than cleaning linoleum floors to reduce organophosphorus (OP) pesticide. The study assessed the effectiveness of cleaning windowsills, floors, and carpets in farmworkers' homes. Researchers collected measures of OP pesticide residues before and 24-48 hours after a standardized cleaning intervention and 12 months later. House dust was analyzed for six OP pesticides. All homes had detectable baseline levels of OP pesticides on floors and windowsills. Cleaning of linoleum floors was ineffective in removing total pesticide residues, and cleaning effectiveness varied among the pesticides; but steam cleaning carpets was successful in reducing OP pesticides to

¹⁵ National Center for Healthy Housing, "Comparing Green Building Guidelines and Healthy Homes Principles: A Preliminary Investigation," 2006. See www.centerforhealthyhousing.org/html/green_analysis.htm.

¹⁶ Foarde K, Berry M. "Comparison of biocontaminant levels associated with hard vs. carpet floors in nonproblem schools: results of a year long study." *J Expo Anal Environ Epidemiol*. 2004; 14 Suppl 1:S41-8 (ISSN: 1053-4245).

¹⁷ Braun, W.X., et al. "Indoor pollutant measuring and modeling comparing impact surface characteristics." *Proceedings of the 7th International Conference on Indoor Air Quality and Climate*, Monterey, CA. 2002.

¹⁸ Wilson J., et al. Unpublished Data. National Center for Healthy Housing.

¹⁹ Lanphear BP, Emond E, Weitzman M, Jacobs DE, Tanner M, Winter N, Yakir B, Eberly S. *A Side-By-Side Comparison of Dust Collection Methods for Sampling Lead-Contaminated House Dust*, Environ Res 68, 114-123, 1995.

non-detectable levels. Twelve months later, the OP levels in carpets had re-accumulated to one-third of the baseline levels.²⁰

Selecting Less Toxic Materials

The chemicals used in the manufacturing of carpeting and padding may release volatile organic compounds (VOCs) through a process known as off-gassing. Carpeting can release volatile organic compounds into the air, especially when first installed. Some of these VOCs, both individually and in certain groups, can impact resident health, especially the respiratory system. VOC levels tend to drop quickly over time. Recent research has focused on specific volatile organic compounds, instead of “total” volatile organic compounds, because the latter includes a large and poorly characterized number of other chemicals. Increased attention is being paid to the reaction characteristics of individual VOCs or groups of VOCs (like aldehydes and alkenes) that are likely associated with adverse health effects or irritation.^{21, 22}

In response, the carpet industry has reformulated carpets to reduce VOC emissions and may air out the carpets before installation. The Carpet and Rug Institute (CRI) sets voluntary industry standards for carpets and rugs. See www.carpet-rug.org. Carpets with the Green Label (or Green Label Plus for more stringent criteria) may have lower VOC levels and those VOCs may be less toxic. See www.carpet-rug.com/residential-customers/selecting-the-right-carpet-or-rug/green-label.cfm for more information on the CRI Green Label program.

Concerns have also been cited about certain alternatives to carpet, specifically polyvinyl chloride (PVC) floor coverings and other plastic floor coverings containing phthalates. A Finnish study found an association between indoor air quality complaints and a high rate of new adult-onset asthma and wet, deteriorating polyvinyl chloride floor coverings. Symptomatic improvement was measured after removal of the vinyl floor covering.²³

The Asthma Regional Council has prepared a detailed index of flooring options outlining health implications particularly for asthma, costs, maintenance considerations, and pollution created during flooring production. See www.astharegionalcouncil.org/about/Flooring_matrix.pdf.

Maintaining Carpets

Cleaning of carpets and bare surfaces contributes to improved indoor air quality by reducing airborne particulate, allergen, bacteria, and fungi and perhaps other substances.^{24, 25} Regular vacuuming can lower allergen levels in carpets substantially,²⁶ and a HEPA vacuum has been shown to be more effective than a conventional vacuum.²⁷

²⁰ McCauley L.A., Travers R., Lasarev M., Muniz J., and Nailon R. “Effectiveness of cleaning practices in removing pesticides from home environments.” *J Agromedicine*. 2006;11(2):81-8.

²¹ Wolkoff, et al. *Indoor Air* 16. 7-19 2006.

²² Singer, et al. *Indoor Air* 16. 179-191. 2006.

²³ Youminen and Seuri. “Indoor Air Quality and health problems associated with damp floor coverings.” *Int Arch Occup Environ Health*. 2004; 77(3): 222-6.

²⁴ Cole E.C., Dulaney P.D., Leese K.E., Hall R.M., Foarde K.K., Franke D.L., Myers E.M., and Berry M.A. (1996) “Biopollutant samples and analysis of indoor surface dusts: Characterizing sources of indoor air pollution and related sink effects.” In: Technor BA (ed.) “Characterizing sources of indoor pollution and related sink effects.” *ASTM STP 1287*, American Society of Testing Material, Philadelphia, PA, pp 153–164.

²⁵ Franke DL, Cole EC, Leese KE, Foarde KK, Berry MA (1997) Cleaning for improved air quality: an initial assessment of effectiveness. *Indoor Air* 7:41–54.

²⁶ Adilah N., Fitzharris P., Crane J., and Siebers R.W. “The effect of frequent vacuum cleaning on the house dust mite allergen,

A recommended frequency of vacuuming is once or twice a week.²⁸ White and Dingle²⁹ showed that intensive carpet cleaning resulted in a 50% reduction in airborne fine particles, similar to levels seen outdoors. This reduction was accomplished by one intense cleaning, defined as vacuuming with a HEPA vacuum for four minutes per square meter (m²), followed by moderate intensity cleanings (one minute/m²) every other week.

Despite the potential benefits of regular vacuuming, recent research has demonstrated that both vacuuming and mechanical agitation (resulting from the physical contact and movement of the vacuum cleaner with flooring surfaces) result in significant increases in coarse particulate matter (PM₁₀) both during and following vacuuming.³⁰ Although coarse particulate matter concentrations began to decline slowly when the vacuuming ceased, the study demonstrated that, on average, particulate concentrations remained higher than pre-background level for two hours after vacuuming had stopped. The same study also confirmed previous research that suggests that vacuum cleaner design plays an integral role in particle emissions. The use of a 12-amp vacuum with a triple filter system and brush roller resulted in statistically significant differences in the particulate concentrations generated during vacuuming. Thus, while vacuuming can help to lower allergen levels, individuals sensitive to dust should stay out of the room both during and directly following vacuuming and should use HEPA vacuums whenever possible.

Another adjunct to vacuuming alone is steam cleaning. Steam cleaning is likely to be more effective against dust mites and does not require the use of pesticides. It also leaves minimal moisture behind, thereby minimizing chances for mold growth, although steps to completely dry the carpet should still be used. Yiin et al found that slow and steady HEPA vacuuming with the help of a dust “indicator” reduces surface and overall lead dust in carpets, and dry steam cleaning further reduces surface lead contamination, compared to HEPA vacuuming alone.³¹

Dry steam cleaning may be a better choice than a standard hot water extraction cleaning method. It applies hot steam (180 °F) so that the surface of the carpet dries within a shorter period of time. Moreover, the carpet backing remains dry throughout the procedure. In a study by Vojta et al, both dry steam-cleaning plus vacuuming and vacuuming alone resulted in a significant reduction in carpet dust mite allergen concentration and load (p < 0.05). However, allergen levels approached pretreatment values by four weeks post-treatment in the intensive vacuuming group, whereas the effects of steam cleaning persisted for up to eight weeks.³²

Der p 1 in carpets: a pilot study.” Department of Medicine, Wellington School of Medicine. 1: *N Z Med J*. 1997 Nov 28; 110(1056):438-9.

²⁷ Popplewell E.J., Innes V.A., Lloyd -Hughes S., Jenkins E.L., Khdir K., Bryant T.N., Warner J.O., and Warner J.A. “The effect of high-efficiency and standard vacuum-cleaners on mite, cat and dog allergen levels and clinical progress.” *Pediatr Allergy Immunol*. 2000; 11(3):142-8 (ISSN: 0905-6157).

²⁸ EPR-3. “Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma.” National Heart, Lung, and Blood Institute; National Asthma Education and Prevention Program. US Dept. of Health and Human Services. Bethesda, MD. 2007.

²⁹ White, K. and Dingle, P. “The Effect of Intensive Vacuuming on Indoor PM Mass Concentration.” *Proceedings, Indoor Air 2002: 9th International Conference on Indoor Air Quality and Climate*. Pp. 92-97. Monterey, CA.

³⁰ Corsi R.L., Siegel J.A., and Chiang C. “Particle Resuspension During the Use of Vacuum Cleaners on Residential Carpet.” *Journal of Occupational and Environmental Hygiene*. 2008 Apr; 5:232-238.

³¹ Lih-Ming Yiin, Chang Ho Yu, Peter Ashley, and George Rhoads. “Cleaning Efficacy of High-Efficiency Particulate Air Filtered Vacuuming and ‘Dry Steam’ Cleaning on Carpet.” *Journal of Occupational and Environmental Hygiene*, 5: 94-99.

³² Vojta PJ, Randels S.P., Stout J., Muilenberg M., Burge H.A., Lynn H., Mitchell H., O'Connor G.T., Zeldin. “Effects of physical interventions on house dust mite allergen levels in carpet, bed, and upholstery dust in low-income, urban homes.” *Environ Health Perspect*. 2001 Aug; 109(8):815-9.

The use of mite-killing agents (acaracides) has yielded mixed results. One study found an acaracide to be ineffective at reducing mite allergen levels over time.³³ Other studies have shown acaracides to be effective, at least for short periods.³⁴ The use of acaracides is generally discouraged for consumers, and states will usually require only licensed pesticide applicators to use such products in homes. Other studies found that using a solution of alum, sprayed on carpet, together with weekly vacuuming, was more effective than vacuuming alone in reducing mites and mite allergen levels.^{35, 36} Regarding lead poisoning, many studies show a positive correlation between lead levels in carpet and children's blood lead levels.³⁷ Chronically lead-contaminated carpets may show increased lead levels compared to hard flooring if vacuuming is not thorough, because embedded lead from the depths of the carpet may be brought to the surface and may remain there.

Selecting a Vacuum - The best vacuums will have HEPA filters to reduce dust that is emitted by the vacuum exhaust. The cost for vacuums containing such filters ranges from less than \$100 to more than \$1,000. Some of the difference may be due to the various features and accessories that come with the vacuum. At the low end of costs, the difference may reflect the use of a relatively small motor that creates the vacuum's suction. Vacuums with relatively weak motors may not deliver satisfactory performance, because the suction will not be sufficient to adequately pull dust and debris from the depths of the carpet. At the other end of the spectrum, costly vacuums may be "overqualified" for the task and not appropriate for those on limited budgets.

How does one select a vacuum that is up to the task of removing small particles embedded in carpet? The best approach is to refer to organizations such as Consumers Union, which conducts laboratory testing of various products. In a recent series of tests, the top five performing vacuum cleaners costing between \$150 and \$500 actually outperformed a unit costing \$1,350.³⁸ You can find references to articles and consumer information on the *Consumer Reports* website at www.consumerreports.org/cro. Full online articles are available to subscribers and at most public libraries.

Implementing Cleaning and Other Home Intervention Protocols - Residents are not always likely, willing, or able to adhere to a regular vacuuming schedule. When researchers incorporated social marketing principles into the educational process to promote a cleaning regimen in urban households, parental compliance improved and allergen and asthma reductions were achieved for carpeted and non-carpeted floors. Moreover, residents experienced fewer asthma symptoms over an extended period.³⁹

³³ Moira C.Y., Ferguson A., Dimich-Ward H., Watson W., Manfreda J., Becker A. "Effectiveness of and compliance to intervention measures in reducing house dust and cat allergen levels." *Ann Allergy Asthma Immunol.* 2002; 88(1):52-8 (ISSN: 1081-1206).

³⁴ Insert acaracide reference on effectiveness.

³⁵ Codina R., Lockey R.F., Diwadkar R., Mobly L.L., Godfrey S. "Disodium octaborate tetrahydrate (DOT) application and vacuum cleaning, a combined strategy to control house dust mites." *Allergy.* 2003; 58(4):318-24 (ISSN: 0105-4538).

³⁶ Sevki C., Levent A., Ender G., Firdevs M. "Reduction of house-dust mite allergen concentrations in carpets by aluminium potassium sulfate dodecahydrate (alum)." *Allergy Asthma Proc.* 2006; 27(5):350-3 (ISSN: 1088-5412).

³⁷ USEPA.(b) *Summary and Assessment of Published Information on Determining Lead Exposures and Mitigating Lead Hazards Associated with Dust and Soil in Residential Carpets, Furniture, and Forced Air Ducts.* USEPA 1997. EPA 747-S-97-01. Washington, DC.

³⁸ Consumers Union. "Vacuums: Cleaning vs. Allergy Claims." 2007; *Consumer Reports*, Mt Vernon, NY. October: 39-41.

³⁹ Morgan W. J., Crain E.F., Gruchalla R.S. et al. "Results of a home-based environmental intervention among urban children with asthma." *New England J. Med.* 2004; 351(11): 1068 – 1080.

For allergy or asthma sufferers, carpet is not the only important furnishing to be maintained and kept clean. Bedding, drapes, upholstered furniture, and pets are also sources of exposure. In addition to vacuuming and cleaning, moisture management, clutter control, and pest management are important allergen avoidance strategies. Elimination of a single or “most important” trigger may not provide improvement.⁴⁰ As demonstrated in the Inner City Asthma Study,⁴¹ an effective approach relied on community-based educators to teach exposure avoidance behaviors. For each mitigation behavior recommended for a particular household, training was designed to “...provide information to the caretaker on the efficacy of the behavior, model the targeted behavior, have the caretaker rehearse the behavior with feedback, establish that the caretaker had mastered the behavior, and increase the caretaker’s outcome expectancies and self-efficacy for the behavior.” The study showed declines in asthma symptoms among atopic children as a result of reducing allergens in the home. Specifically, an intervention costing in the range of \$1,500 to \$2,000 per child resulted in 2.1 fewer unscheduled doctor visits per year, 21.3 fewer days with symptoms per year, and 4.4 fewer missed school days per year.⁴²

Additional studies have demonstrated the ability of asthma interventions to reduce urgent health care utilization and generate medical cost savings. A study by Karnick et al sought to identify potential cost-savings to the Illinois Department of Healthcare and Family Services (the state’s Medicaid administrator) generated from the provision of asthma case management to their pediatric clients with asthma.⁴³ The program provided 70 children with full case management services, which included asthma trigger identification and the development of an action plan for the child’s family. The study estimated that total healthcare costs, measured in reimbursement dollars by the Illinois Department of Healthcare and Family Services, decreased from \$6,905 per child per year to \$1,739. Taking into account the intervention program costs, the study estimated total program cost savings per person at \$4,503 annually.

In a study by Krieger et al., community health workers provided participants with allergy control pillow and mattress encasements, low-emission vacuums, commercial-quality door mats, cleaning kits, referrals to smoking cessation counseling, roach bait, rodent traps, assistance with roach and rodent eradication, and advocacy for improved housing conditions. This high-intensity group improved significantly more in its pediatric asthma caregiver quality-of-life score (P=.005) and asthma-related urgent health services use (P=.026) than its counterparts in the low-intensity group, which received a single community health worker visit, a home environmental assessment, an action plan, limited education, and bedding encasements.⁴⁴ The decline in urgent health services demonstrated in the high-intensity intervention was estimated to result in a cost savings of \$201-\$334 per child in the two month study period.

A recent study conducted by English researchers examined whether a household intervention aimed at reducing exposure to house dust mites could reduce the incidence of asthma in high-risk children or reduce severity of

⁴⁰ Danov Z. and Guilbert T.W. “Prevention of asthma in childhood.” *Curr Opin Allergy Clin Immunol.* 2007;7(2). 174-179.

⁴¹ Crain et al. “Home and Allergic Characteristics of Children with Asthma in Seven U.S. Urban Communities and Design of an Environmental Intervention: The Inner City Asthma Study.” *Environ. Health Perspect.* 2002; 101(9):939-945.

⁴² Id.

⁴³ Karnick P., Margellos-Anast H., Seals G., Whitman S., Aljadeff G., and Johnson D. “The Pediatric Asthma Intervention: A Comprehensive Cost-Effective Approach to Asthma Management in a Disadvantaged Inner-City Community.” *Journal of Asthma.* 2007 January; 44:39-44.

⁴⁴ Krieger JW, Takaro TK, Song L, Weaver M. Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County Healthy Homes Project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. *Am J Public Health.* 2005 Apr;95(4):652-9.

asthma in people already diagnosed. The results showed a significant reduction in physician diagnosed asthma and a reduction in asthma symptom days as a result of the interventions.⁴⁵

Conclusion

Carpeting provides a soft surface that can reduce slips, which in turn can help to reduce the severity of injuries from falls. Carpeting absorbs noise; however, carpets also trap dirt, pet dander, pollen, pesticides, lead-dust, food, moisture, and can harbor pests associated with asthma, such as cockroaches and dust mites.^{46, 47} These contaminants can be re-released into the home environment, especially when vacuuming with a low-quality vacuum, when carpeting is removed, when a child is playing on it, or when it is otherwise disturbed.^{48, 49, 50}

Some types of hard flooring are easier to clean and are likely to accumulate less dust, yet may also contain certain plasticizers (phthalates), which have been linked to asthma and disruption of endocrine function. In high traffic areas and heavy use homes, carpet may need replacement every five to seven years. As such, although carpet may be less expensive initially, it may be more expensive to maintain over time. Carpet is typically not recommended for individuals with asthma or allergies. However, if carpet cannot be replaced, careful cleaning can reduce the risks from allergens, asthma triggers, and other contaminants.

Many thanks to these individuals, who provided expert feedback on this document:

Dr. Peter Ashley, U.S. Department of Housing and Urban Development

Ms. Karen Cohn, San Francisco Department of Health

Dr. Dorr Dearborn, Case Western Reserve University

Dr. David Miller, Carleton University

Dr. Philip Morey, Boelter and Associates

Ms. Sharon Pendleton, Housing Consultant

Dr. Richard Shaughnessy, University of Tulsa

Dr. Tim Takaro, Simon Fraser University

Mr. Jonathan Wilson, National Center for Healthy Housing

⁴⁵ Russell C, Sternberg A., and Hunter P.R. “A systematic review and meta analysis of interventions aimed at reducing exposure to house dust on the development and severity of asthma.” Available at <http://dx.doi.org>. Online 25 September 2007.

⁴⁶ Simpson A, Hassall R, Custovic A, Woodcock A. “Variability of house-dust-mite allergen levels within carpets.” *Allergy* 1998;53(6):602-7.

⁴⁷ National Academies Press, 2000. *Clearing the Air: Asthma and Indoor Air Exposures. Executive Summary Institute of Medicine.* ISBN 0-309-06496-1. See www.nap.edu/books/0309064961/html/.

⁴⁸ Cho SH, Reponen T, Bernstein DI, Olds R, Levin L, Liu X, Wilson K, Lemasters G. “The effect of home characteristics on dust antigen concentrations and loads in homes.” *Sci Total Environ.* 2006; 371(1-3):31-43 (ISSN: 0048-9697).

⁴⁹ USEPA.(a) *Lead Exposure Associated With Remodeling Activities.* USEPA 1997 EPA 747-R-96-005. Washington, D.C.

⁵⁰ Platts-Mills, T.A.E., et al. “The Role of Intervention in Established allergy: Avoidance of Indoor Allergens in the Treatment of chronic Allergic Disease.” *J. Allergy Clin. Immunol.*2000;106:787-804.