

# PERCEIVED EFFECTS OF CARPET ON INDOOR AIR QUALITY

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## Abstract

*The purpose of this study was to examine the effects of carpet on indoor air quality (IAQ) as perceived by practicing interior designers. A mail survey of 440 Rocky Mountain area designers was conducted. Findings revealed that designers perceived that carpet affected both IAQ and occupants' health, and that glues/adhesives and finishing chemicals were the carpet items most considered to affect IAQ. A minority of respondents felt that they had adequate IAQ information or actively searched for IAQ information. Statistically significant relationships existed between IAQ perceptions of carpet in general, IAQ information, and IAQ perceptions of specific carpet items.*

## Introduction

Built-environment professionals can play an important role in reducing residential indoor air quality (IAQ) problems. Among the various strategies available, the careful specification of building materials is one effective method to reduce the quantities of indoor-generated pollution (El Diasty & Olson, 1993). A major factor in determining a building material's contribution to IAQ is the total amount of the material used and the composition of that material (Pilatowicz, 1995). Consequently, materials with the greatest surface area and those containing relatively high concentrations of volatile organic compounds (VOCs) should be a major concern in decision-making (American Institute of Architects, 1993). Among residential interior components, the floor typically repre-

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sents between 15-25% of total surface area; thus, specification of the floor covering product is significant to IAQ.

The U. S. Environmental Protection Agency (EPA) has developed a comprehensive program to address sources of indoor air pollution that affect IAQ (EPA, 1993). Recently, the EPA and the U. S. Department of Agriculture launched a national initiative entitled "Healthy Indoor Air For America's Homes" to deliver IAQ information to the public through Cooperative Extension (Parrott, Bode, Laquatra, Ponessa, Seifert, Vogel, Wysocki, & Gwevin, 1996). Carpet is the residential floor covering receiving the greatest amount of attention in these efforts. For example, the Healthy Indoor Air for America's Homes training manual contains carpet information relating to biological contaminants and includes two brochures focusing on carpet (Vogel, 1996).

The purpose of this research was to examine the effects of carpet on IAQ as perceived by practicing interior designers. Interior designers were selected for study because IAQ has been identified as an important issue for the design profession (Guerin, 1992); interior designers assist consumers and builders in making floor-covering decisions; and many academic housing programs provide classes to interior design students (e.g., alternative housing and sustainable housing design). Additionally, all academic interior design programs accredited by the Foundation for Interior Design Education Research (FIDER) must meet standards in teaching their students about building materials and environmental issues, including IAQ as well as occupants' health and safety (FIDER, 1996). Certified and licensed interior designers also gain continuing education credits throughout their careers, and these can include IAQ-related courses and programs offered by professional associations.

In this study four research questions were examined:

- (1) Do interior designers perceive carpet as affecting IAQ?
- (2) What carpet-related items are perceived by interior designers as most seriously affecting IAQ?
- (3) Do interior designers actively search for information on IAQ and feel that they have adequate IAQ information?
- (4) Do relationships exist among interior designers' perceptions of carpet's effects on IAQ and occupants' health, IAQ information, and perceptions of carpet-related items' effects on IAQ?

### **Literature Review**

Some controversy exists regarding the extent to which carpet influences IAQ in the residential environment. On the one hand, EPA and other concerned groups have targeted carpet as one of the significant IAQ problems found in homes (Wilson, 1995). Wall-to-wall carpet can emit volatili organic compounds (VOCs) into the air or otherwise be a source of indoor air pollution (e.g., harbor mold spores, dust mites, and lead-based paint flakes) (EPA, 1992). According to experimental research, a link between exposure to chemicals and higher cancer rates exists among carpet industry employees (Daley, 1992). A test on carpet toxicity conducted by Anderson Labs (1991) found that some carpets can release agents capable of causing neurological toxicity and death in

mice. The laboratory results supported human complaints that emissions from particular carpets can cause adverse health effects (Leslie & Lunau, 1992). However, subsequent research investigations did not support the Anderson Labs findings (Stadler, Dudek, Kaempfe Christoph & Hansen, 1997; Tepper, Moser, Costa, Mason, Roach, Guo, & Dyer, 1995) and an extensive review of research on carpet emissions by Dietert and Hedge (1996) led to the conclusion that carpet emissions do exist, but below the level of toxicity and that perceived effects from carpet emissions were influenced by many non-environmental conditions. Thus, the issue of carpet emissions is not resolved.

Potentially toxic substances in carpet, particularly in the glues and backings, include styrene, acetone, methylcyclopentane, n-octane, n-dodecane, toluene, xylene, formaldehyde, 4-phenylcyclohexene, and a variety of benzenes. These VOCs result in new carpet being a well-recognized initial sensitizer for some individuals. Carpets also emit gas from dyes and substances added to the fibers, releasing particulates that can be breathed into the lungs (Ponessa, 1992). New carpet especially can contribute to health difficulties for chemically sensitive persons. Some symptoms possible from contact with carpets that emit high levels of VOCs are asthma, hoarseness, nausea, and impaired consciousness (Matthews, 1992).

According to the National Jewish Center for Immunology and Respiratory Medicine, carpet traps allergens at 100 times the rate of a bare polished floor (Linne, 1994). In addition, mite and fungus contamination can be caused by a continuously damp carpet; such dampness may occur when carpet has been installed on poorly ventilated concrete floors (EPA, 1994). Wall-to-wall carpet can be a reservoir (described by some as a "sink") for biological and chemical contaminants, and vacuum cleaning is typically not an effective intervention (Barnet & Browning, 1995). According to the American Lung Association: "Carpet can become a collector of airborne pollutants, as well as of substances that may be tracked or spilled. Studies have found biological pollutants such as bacteria, mites and fungi, and carcinogens such as lead, chlordane, and even DDT in carpet" (1992, p. 1).

The EPA has engaged in an extensive dialogue with the carpet industry, public interest groups, and other federal government agencies to explore techniques for reducing the emission of VOCs from new carpet and related installation materials, such as carpet cushions and adhesives. As a result of this effort, the carpet industry agreed to test new carpet materials for total VOC emissions and to provide information on carpet and IAQ to consumers (EPA, 1993). As stated by The Carpet and Rug Institute (CRI): "The carpet industry is proud to participate in an effort to find ways to lower emissions and minimize the impact of carpet on indoor-air-quality and has developed an indoor air quality carpet-testing program to do so. This program cannot guarantee good health because everyone reacts differently, but it does tell you that the people making carpet are working very hard to minimize the impact of carpet on indoor air quality" (1995, p. 2). Strategies that enable building occupants to avoid exposure to chemical emissions from carpet were suggested by both EPA (1992) and CRI (1993). A CRI green tag is now placed on new carpets that meet IAQ standards, and a videotape and guide have been released to assist consumers in selecting environmentally friendly carpet.

Although the probability that building occupants will experience serious long-term health problems from exposure to new carpet is minimal (American Lung Association, 1992; Sarnet & Spengler, 1991), interior designers can reduce the possibility by selecting carpet containing a CRI green tag. The green tag essentially means that a carpet manufacturer participates in the CRI indoor-air-quality carpet testing program and that a sample of the carpet product type has been tested by an independent laboratory for certain chemical emissions. If adhesives and cushions are used, interior designers can select those with minimal levels of VOCs. Professional design magazines such as *Interiors & Sources*, *EnvironDesign Journal*, *Interior Design*, and *Interiors* are increasingly advertising and reviewing carpet, adhesives, and cushions based on IAQ concerns.

Following certain precautions in the installation of new carpet is also important to IAQ. Brochures available for use by interior designers, carpet retailers, and installers as well as consumers include the American Lung Association's (1992) *Indoor air pollution fact sheet: Carpet*, CRI's (1993) *Carpet owner's manual*, EPA's (1992) *Indoor air quality and new carpet*, and the U. S. Consumer Product Safety Commission's (1993) *Tips for purchasing and installing new carpet*. Interior designers need to ask the retailer to unroll and air out carpet in a well-ventilated area before installation and then instruct the installer to follow industry installation guidelines (Residential Carpet Installation Standard, CRI-105). Carpet purchasers also need to be informed by interior designers to ventilate the space with fresh air during all phases of installation and for at least 72 hours afterwards, vacuum the existing carpet before removal to minimize the amount of dust particles, vacuum the floor after the old carpet and cushion have been removed, and ask persons who are allergy prone or sensitive to odors or chemicals to avoid the space when these materials are being installed or removed.

Carpet maintenance is important for IAQ because floor coverings are subject to more wear and tear than any other residential interior component. Based on the information contained in the above carpet brochures, recommendations offered by interior designers to carpet purchasers should include: promptly and thoroughly clean spills, keep carpet dry, vacuum at least twice weekly, use a vacuum cleaner with strong suction and good filtration (preferably with a microfiltration bag), use doormats at entrances to reduce tracked-in dirt, have the carpet professionally cleaned at least once every 12-18 months, and follow additional manufacturer instructions.

With regard to the above issues, it is important to determine if interior designers are informed and concerned about IAQ and carpet, as it can be suggested that interior designers need to be more selective when specifying carpet. As recommended by the American Society of Interior Designers (ASID, 1994), designers are encouraged to develop product and material files that provide current, adequate information on the environmental effects of the materials used in products specified in their work. Certainly these files should include IAQ information on carpet. Interior designers also need to understand and apply carpet installation and maintenance guidelines. In this effort interior designers can collect and file carpet brochures and related information, and can maintain sufficient quantities of carpet brochures to provide to retailers, installers, and carpet purchasers.

### Methodology

The sample frame for this study consisted of the 1,006 interior designers listed in the 1995 ASID directory as practicing in seven Rocky Mountain area states: Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming. Mailing labels for these designers were purchased from ASID. An eight-page questionnaire addressing a variety of environmental concerns with a cover letter and a stamped return envelope was mailed to each designer during summer, 1995. Using elements of the total design method (Dillman, 1978), a postcard reminder was mailed to all sample members two weeks after the questionnaire was sent. A second questionnaire was mailed to nonrespondents four weeks after initial contact.

Of the 1,006 questionnaires mailed, 18 were returned as undeliverable. An additional 124 questionnaires were deleted because potential respondents indicated that they did not specify floor coverings or were no longer active in the interior design profession. Of the remaining 864 that could be completed, a total of 440 questionnaires were completed and returned (51% response rate).

### Results and Discussion

Two survey questions addressed Research Question One. First, respondents were asked how seriously carpet affects IAQ (scored 1 = very seriously to 4 = not seriously). Responses were as follows:

Very Seriously	46.0%
Seriously	32.1%
Somewhat Seriously	18.4%
Not Seriously	3.5%

Based on the four-point Likert-item scale, the mean was 1.79 and the standard deviation was .86. Next, respondents were asked how often carpet affects IAQ and, therefore, occupants' health (scored 1 = always to 4 = never), with the following results:

Always	20.3%
Frequently	53.6%
Rarely	25.9%
Never	0.2%

The mean was 2.06 and the standard deviation was .69. Approximately three-fourths of the respondents, then, perceived that carpet seriously or very seriously affects IAQ, and that carpet always or frequently affects occupants' health. Respondents were slightly more likely to perceive carpet as affecting IAQ as opposed to directly affecting occupants' health.

Research Question Two addressed interior designers' perceptions of the various components of carpet in terms of their effects on IAQ. Carpet-related items were selected based on the literature reported earlier. Respondents were asked: In your view, how seriously do the following carpet-related items (from manufacturing to post-installation) affect IAQ? Utilizing a four-point Likert-item scale, responses ranged from "very seriously" (scored as 1) to "not seriously" (scored as 4) for the eight items. Results are displayed in Table 1.

If only the “very seriously” response category is considered, it is apparent that respondents made major distinctions between the carpet-related items. The two items considered to most seriously affect IAQ were glues/adhesives (75.1%; mean = 1.32) and finishing chemicals (73.6%; mean = 1.33). This level of concern is consistent with research on offgassing problems with new carpet. The next clustering consisted of cleaning products (59.7%; mean = 1.55) and biological contaminants residing in carpet (52.4%; mean = 1.69). These are two recognized IAQ problems associated with existing carpet. About one-third of the respondents answered “very seriously” regarding padding (37.1%; mean = 1.89) and synthetic fibers (31.2%; mean = 2.16). This result was followed by vacuuming (22.0%; mean = 2.44) and natural fibers (9.4%; mean = 3.00). Standard deviations were below one in all but one instance (i.e., vacuuming).

Research Question Three considered if interior designers felt that they had adequate information on IAQ and if they actively searched for IAQ information. In the questionnaire respondents were asked: Do you feel you have adequate information on IAQ? Responses were scored as 1 for “yes” and 2 for “no”, with these results:

Yes	9.6%
No	90.4%

Respondents were then asked: Do you actively search for IAQ information? Responses were again scored as 1 for “yes” and 2 for “no”, with the following results:

Yes	27.5%
No	72.5%

Approximately one-tenth of the respondents, then, felt that they had adequate information on IAQ and slightly over one-fourth of the respondents actively searched for that information.

To address Research Question Four, perceptions of carpet’s effects on IAQ and occupants’ health as well as the IAQ information responses were correlated with perceptions of carpet-related items’ effects on IAQ. Correlation coefficients were computed to measure the strength and direction of relationships, and are shown in Table 2. Results reveal that those respondents who were more likely to view carpet as seriously affecting IAQ were also more likely to view all eight carpet-related items as seriously affecting IAQ. Correlation coefficients ranged from lows of .21 for vacuuming and .29 for biological contaminants in carpet to a high of .48 for both synthetic and natural fibers. All were statistically significant at the  $p < .01$  level.

Respondents who were more likely to think that carpet often affects IAQ and, therefore, occupants’ health were also more likely to view all eight carpet-related items as seriously affecting IAQ. Correlations ranged from a low of .25 for both vacuuming and cleaning products to a high of .36 for both synthetic and natural fibers. Again, all were statistically significant at the  $p < .01$  level.

Respondents who felt that they had adequate information on IAQ were slightly more likely to view carpet-related items as seriously affecting IAQ. Correlation coefficients ranged from a low of .06 for natural fibers to a high of .15 for finishing chemicals, with two of the correlations statistically significant at the  $p < .05$  level. Results also reveal that respondents who actively searched for IAQ information were more

**Table 1. Extent to Which Carpet-Related Items Were Viewed as Affecting IAQ**

Carpet-Related Items	Seriousness of Effect					Mean	Standard Deviation
	(n)	Very Seriously	Somewhat Seriously	Not Seriously	Percentage		
		Seriously	Seriously	Seriously			
Glues/Adhesives	(419)	75.1	18.2	5.6	1.2	1.32	0.64
Finishing Chemicals	(427)	73.6	20.6	4.9	0.9	1.33	0.61
Cleaning Products	(427)	59.7	27.9	10.5	1.9	1.55	0.75
Biological Contaminants in Carpet	(422)	52.4	29.1	15.9	2.6	1.69	0.83
Padding	(421)	37.1	40.9	17.8	4.3	1.89	0.84
Synthetic Fibers	(423)	31.2	32.3	26.0	10.6	2.16	0.99
Vacuuuming	(419)	22.0	31.5	27.4	19.1	2.44	1.03
Natural Fibers	(426)	9.4	19.7	32.6	38.3	3.00	0.98

**Table 2. Correlations between Perceptions of IAQ Effects of Carpet, Occupants' Health Effects of Carpet, Adequate IAQ Information and Search for IAQ Information, and Carpet-Related Items Effects on IAQ**

Carpet-Related Items	Affects IAQ	Affects Health	Adequate Information	Information Search
r				
Glues/Adhesives	.46**	.32**	.08	.19**
Finishing Chemicals	.47**	.34**	.15*	.10*
Cleaning Products	.36**	.25**	.08	.12*
Biological Contaminants in Carpet	.29**	.31**	.09	.20**
Padding	.43**	.30**	.08	.14**
Synthetic Fibers	.48**	.36**	.12*	.11*
Vacuuming	.21**	.25**	.07	.11*
Natural Fibers	.48**	.36**	.06	.03

\* $p < .05$     \*\* $p < .01$

likely to view the eight carpet-related items as seriously affecting IAQ. Correlation coefficients ranged from a low of .03 for natural fibers to a high of .20 for biological contaminants in carpet. Four of the correlations were statistically significant at the  $p < .05$  level and three at the  $p < .01$  level.

### Conclusions and Recommendations

In summary, interior designers, as reflected by the study's respondents, appear to be concerned about the impact of carpet on IAQ. About three-fourths of the respondents perceived that carpet either very seriously or seriously affects IAQ, and that carpet either always or frequently affects occupants' health. Glues/adhesives and finishing chemicals were most likely to be considered as the carpet-related items affecting IAQ. However, only about one-tenth of the respondents felt that they had adequate information on IAQ, and one-fourth actively searched for IAQ information. As concern for



general carpet effects on IAQ and occupants' health increased, and as adequacy and search for IAQ information increased, so did concern for a variety of specific carpet-related items.

There exist growing expectations for built-environment professionals to consider the IAQ impacts of materials used in housing. In the case of carpet, accurate research and recommendations are needed. As revealed in this research, interior designers are aware of and concerned about carpet and IAQ. Practicing interior designers are in a position in which they can significantly influence the material selection, installation methods, and maintenance used for floor coverings. Given their concern for carpet and IAQ as well as their feelings about IAQ information, current information must be accessible in an applied format for interior designers. Additionally, both practitioners and educators need to be familiar with IAQ issues and recommended approaches in order for them to reduce indoor air problems associated with carpet. Finally, housing and interior design educators should incorporate IAQ research findings into their courses and should help students develop a process to keep abreast of information on IAQ and carpet.

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