The relationship between carpet, indoor air quality, and health has received considerable attention in the media. Many people are exposed to carpet for extended periods in the home, school, or workplace. A lot of children in child care centers are exposed to carpet because many centers use carpets to provide soft surfaces, which is desirable. In fact, more than 1 billion square yards of carpet to be used as floor covering are sold each year in the United States. If exposure to carpet causes adverse health effects, this would concern many people.

Why carpet and indoor air quality are linked

Modern carpet is usually made from synthetic fibers, which are either tufted or woven to a backing. Most carpet used in residential, commercial, or public settings consists of synthetic pile, usually nylon, tufted through a primary backing with a backcoating of water-based adhesive. Other chemicals also are used in the production process. The total chemical composition of final carpet products varies depending on the dyeing process and the addition of treatments, such as stain-resistant and soil-retardant materials. Carpet is usually installed as part of a system that includes the carpet and other products such as carpet cushion, seam sealant, and/or floor adhesive.

When new synthetic carpet is first installed, it releases small amounts of some volatile organic compounds (VOCs) into indoor air. The testing and labeling program currently used by the carpet industry was developed in conjunction with the Environmental Protection Agency. This program has been found to be very reliable. Researchers use this program to test for total VOC (TVOC) emissions. Although new carpet TVOC emissions can range from 3 to 40 different substances, most new carpets have 10 or fewer VOCs. The particular VOCs will depend on the composition and construction of the carpet.

The testing program concentrates on three substances: styrene, 4-PC (4-phenylcyclohexene), and formaldehyde. Carpet usually does not contain formaldehyde, however, both styrene and 4-PC, a nontoxic substance, are...
part of the carpet system and are emitted by the rubber backing found on many new carpets. Although 4-PC may be responsible for some of the odor in new carpet, it and styrene are emitted at very low concentrations. Any other emissions are also at trace levels, and VOCs are nearly totally off-gassed within the first 96 hours after installation. With adequate ventilation, VOC levels will remain low. New carpet also does not emit carcinogens at levels even remotely close to a threshold that would cause concern.

Do other factors affect carpet emissions?

The testing program assumes normal indoor climate conditions. Are VOC emissions affected by variations in climate conditions? For example, do high air temperatures affect VOC carpet emissions? TVOC emission levels will increase substantially when temperatures rise above 120 degrees Fahrenheit. These high temperatures may occur during installation, not during the life of the carpet. Therefore, while air temperature does affect VOC emissions, it is unlikely that conditions in a home, workplace, or school will be sufficient to produce any indoor air problems. Ventilation rate (the number of air changes per hour) also affects the concentration of VOC emissions from new carpet. Essentially, VOC concentrations go up when ventilation is poor. If the area where new carpet is installed is properly ventilated, indoor air quality should not be a problem.

The concentration of ozone can affect VOC carpet emissions. Ozone elevates VOC emissions because it is an oxidizing agent. Exposure to high ozone levels also affects the human immune system, reducing resistance to respiratory diseases and lowering the threshold for pulmonary inflammatory responses. In some urban areas the exposure to ozone is high, which alone may contribute to health problems.

Besides climate-related conditions, what other factors affect new carpet emissions? Researchers have found that TVOC levels usually are much higher from components of the carpet system (carpet cushion, floor adhesive, and/or sealer sealant) than from the carpet itself. In addition, carpet is often installed as part of other renovation work such as carpentry, painting, and wall papering. When TVOC levels from all of these sources were measured, emissions from these renovation-related sources were found to be higher than those from the new carpet. The chart below illustrates the TVOC emission levels of some common indoor materials. In spite of the odors emitted from all of these sources, the VOC levels are still very low.

Other factors that affect VOC emission levels in new carpeting include climate conditions and the carpet system. With the exception of ozone, none of these other factors significantly raise VOC emission levels, however.

Sick Building Syndrome, air quality, and carpet

Sick Building Syndrome (SBS) symptoms—headache, lethargy; eye, nose, and throat irritation; breathing problems; and skin irritation—are linked to building occupancy. The symptoms usually disappear when the person leaves the building. Nevertheless, these symptoms are a problem for the occupants. The indoor air quality (IAQ) of these buildings is thought to be related to the complaints; however, IAQ surveys of such buildings often fail to find any problems. Dust is thought to be related to the indoor air problems and the presence of dust has been found to be correlated with symptoms associated with SBS. In addition, the total amount of VOC in dust has been correlated with occupants' lack of concentration and lethargy.

It is commonly thought that carpet contributes to dust problems. New or existing carpet, however, does not create dirt and dust. Pungi, bacteria, and dust mites do not grow on carpet constituents, and allergens do not proliferate in carpet. Dust mites, however, can be found in carpet. According to researchers, 60 percent of dust mites are found in mattresses, 20 percent in carpet, and 18 percent in soft furnishings. Dust mites are more often a problem when the humidity is high (above 70 percent).

Approximately 15 percent of people in the United States are allergic to dust mites. For these people, carpet may be a problem because of the

TVOC emission levels of some indoor materials

![Graph showing TVOC emission levels of different indoor materials.](image-url)
presence of dust mites. Mites, however, are also present on hard floors, and mite allergen may become airborne more easily with a hard floor. Synthetic carpet traps and holds dust better than wool carpet; therefore, there is less airborne mite allergen with synthetic carpet than with wool carpet. Synthetic carpet may actually be preferred to hard floors for those allergic to dust mites.

So while dust may be associated with SBS symptoms, carpet is not necessarily the culprit. The presence of carpet in buildings where there are IAQ problems may cause office workers or students and teachers to attribute the problems to the carpet. This is especially likely if there is an odor problem. But the problem may be due to inadequate cleaning of the carpet, high moisture, or other possible sources of poor IAQ that are not related to carpet. Some of these other sources are:

- the quality of the outdoor air (gases, particles, bacteria, fungi);
- HVAC design, operation, and maintenance;
- building materials (woods, caulking, adhesives);
- people, odors, clothing;
- smoking, use of correction fluids, cleaning and maintenance practices, pest control practices;
- photocopiers, computers, laser printers;
- finishes (paints, varnishes, wall coverings);
- furnishings (furniture, draperies, floor coverings).

The perception of poor indoor air quality may lead people to report symptoms associated with SBS. Research has shown that the link between IAQ and SBS is influenced greatly by nonenvironmental factors such as occupation, and personal and psychological characteristics. SBS symptoms are usually reported for office buildings or other places of employment; complaints about SBS or poor IAQ in homes are rarely made, yet carpet is present in most homes in this country. This suggests that factors other than carpet are involved in the perception of poor IAQ.

Are there health risks related to carpet?

Exposure to VOCs potentially can have several effects on people including odor, sensory irritation, and mucosal irritation and systemic toxicity, genotoxicity, and carcinogenicity. Therefore, exposure to high enough levels of VOCs can pose health risks. Because newly installed carpet emits VOCs, some concern exists that carpet may be related to health problems. Although persons who think they have a particular sensitivity to pollutants may report experiencing some problems when new carpet is present (eye, nose, and throat irritation; headaches; skin irritation; and fatigue), the likelihood of permanent or serious health effects is minimal. For those without this sensitivity, there should be no symptoms. Therefore, based on all the analyses to date, researchers conclude that VOC emissions from new carpet and the total carpet system do not pose a significant health risk. The emissions detected are low and they are not a factor within a week (96 hours) after installation.

Old carpet does not pose a significant health risk either. Carpet does not create dust. In fact, carpet serves as a better trap for fungi, bacteria, and allergens than other floor coverings. Because these substances only become a problem when they are airborne, carpet may be beneficial to persons allergic to dust.

Carpet is also not a major source of poor indoor air quality. When compared to other indoor materials such as paint and floor wax, carpet has lower TVOC emissions. In addition, several other sources contribute to poor indoor air quality including outdoor sources, activities such as smoking and cooking, photocopiers and printers, improper ventilation, and cleaning practices. Researchers conclude that when carpet is present and there are odors or the perception of poor indoor air quality, carpet is seen as the culprit. Other sources are not readily identified. No definitive scientific link exists, however, between carpet, IAQ, and health risks.

How should carpet be installed and maintained?

Here are some guidelines to follow that help reduce any potential problems with carpet.

Installation of new carpet:

- vacuum old carpet before removal to minimize dispersing dust;
- allow new carpet to “rest” unrolled in a well-ventilated area for at least 24 hours prior to installation;
- purchase low-emitting carpet, cushion, and adhesives;
- ventilate properly—open windows during and after installation, operate ventilation system with maximum outdoor air exchange during and after installation for at least 48 to 72 hours;
- avoid having people (or pets) on the premises during and immediately after the installation, schedule workplace installations when employees are not present.
Maintenance of existing carpet:
- keep carpet dry and clean;
- vacuum regularly with high-efficiency bags;
- use nontoxic cleaners and follow manufacturer's directions carefully, allow carpet to dry fully after wet cleaning;
- clean spills promptly and thoroughly.

Does carpet have benefits?
The benefits of carpet include:
- appearance and feel—provides color, softness, texture, comfort;
- acoustics—makes spaces quieter by absorbing noise, reduces impact noise;
- improves indoor air—traps contaminants better than other floor coverings;
- safe surface—reduces number of serious slips, trips, and falls;
- cost-effective—is cost competitive to purchase, less costly and easier to maintain than other floor coverings.

Current scientific information shows that installing new carpet in homes, schools, or workplaces should not cause concern. Carpet that emits VOCs at or below the criteria specified by the Carpet and Rug Institute's testing and labeling program should not affect indoor air quality to the extent that a health risk is present under normal environmental conditions. Also, aged carpet should not pose a health threat, assuming normal environmental conditions (including proper ventilation) and appropriate care of the carpet. Although carpet and all floor coverings have limitations, the benefits of carpet and the low health risks associated with it make carpet a good choice for a variety of situations.

Additional questions?
If you have additional questions about technical issues related to carpet, indoor air quality, and health, call the Carpet and Rug Institute at 800-882-8846 or 706-258-3112.
For general questions, call Alan Hodge, Cornell University, at 607-255-1957 or Lorraine Maxwell, Cornell University, at 607-255-1958.

References

Future topics
In Facilities Planning and Management Notes, we would like to address concerns of readers involved in the planning, design, and maintenance of facilities. Let us know what topics you'd like to see in future issues.
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