School Floor Coverings: Effects on Children's Well-Being and Learning

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Floor Covering Issues

- How do floor coverings affect indoor air quality?
- How do floor coverings affect safety and the learning environment?

Indoor Air Quality in Schools

- Sources of IAQ problems include:
  - HVAC contamination - a frequent source of indoor air quality problems
  - Microbiological contaminants - usually originate outdoors
  - Water damage
  - Inadequate maintenance
  - Localized sources
School IAQ depends on Many Factors

- Outdoor air quality - gases, particles, bacteria, fungi
- HVAC design, operation and maintenance - air handling units, filters, ducts.
- Building materials - woods, caulk, adhesives, mineral woods
- People - odors, clothing, bioeffluents
- Activities - cooking, labs, correction fluids, cleaning and maintenance practices, pest control
- Technology - copiers, computers, laser printers
- Finishes - paints, varnishes, wall coverings
- Furnishings - furniture, draperies, floor coverings

IAQ and Respiratory Effects

- Research studies repeatedly have shown that people respond to what is in the air in their breathing zone, not what is trapped in surface materials.

Floor Covering Issues

- Source: How are floor coverings a source of some air pollutants?
- Sink: How are floor coverings a reservoir for some air pollutants?
- Safe: How are floor coverings an effective trap for some air pollutants?
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Indoor Air Pollutants

- Volatile Organic Compounds (VOCs)
  - Paints
  - Materials
  - Adhesives
  - Cleaning
  - Equipment
- Biologicals
  - Bacteria, Endotoxin
  - Fungi, Mycotoxins
  - Allergens (Cockroaches, Dust mites, Dogs, Cats)

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New Carpet Emissions

- New carpet can emit a number of volatile organic compounds (VOCs) when first exposed to the air.
- Emissions will vary with the type of carpet.

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TVOC Emissions for New Carpet

When exposed to air, VOC emissions will decay rapidly.
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**TVOC Emission Factors of Some Indoor Materials**

- Paint
- Floor Adhesive
- Floor Wax
- Wall Covering
- Low VOC Adhesive
- Vinyl Flooring
- Carpet

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**New VCT Emissions**

- New VCT can emit a number of volatile organic compounds (VOCs) when first exposed to the air.
- Emissions will vary with the type of VCT and adhesive.

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**Installed VCT and Carpet**

(Black, 1995)
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TVOC Emission Profiles: VCT vs. Carpet
(Black, 1995)

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Carpet Emissions

- Volatile ingredients:
  - Across all types of carpet
  - ~160 different VOCs, but most at trace levels
- No evidence of health effects from numerous studies, including EPA.

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Carpet Cushion
(Shaeffer et al., 1996)

- Carpet cushion emits VOCs.
- Emissions vary by product.
- Average of 75% lower emissions from retail than factory samples of 5 cushion types.
- Average of 63% fall in emissions from 6 to 96 hours.
- Up to 90% fall in emissions when covered by carpet.
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**VOC Pollutants**  
(Washington + Florida AQS Studies)

- VCT and sheet vinyl floor coverings emit more VOCs into the air than carpet.
- Adhesives are the strongest emitters of VOCs in flooring systems.
- Low VOC emitting adhesives can substantially reduce overall emissions.

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**Floor Cleaning and VOCs**  
(Black 1995)

- Cleaning systems for hard surface flooring can contribute substantial amounts of VOCs into the air.
- Carpet cleaning (hot water extraction) emits very low to no VOCs.

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**Carpet System Emissions**

Carpet emissions

Low VOC emissions

Carpet cushion  
Carpet adhesive

Carpet maintenance – Vacuum cleaners
CRI Testing Initiatives

- Carpet emissions testing.
- Carpet cushion emissions testing.
- Carpet adhesive emissions testing.
- Vacuum cleaner testing.

CRI IAQ Carpet Testing Program

- The CRI Indoor Air Quality Testing and Labeling Program pioneered voluntary product emissions testing.
- CRI program tests mill samples for:
  - TVOCs 0.6 mg/m²·hr
  - Styrene 0.4 mg/m²·hr
  - 4-PC 0.1 mg/m²·hr
  - Formaldehyde 0.05 mg/m²·hr
- Emissions criteria developed in conjunction with the Environmental Protection Agency.

CRI Carpet Cushion Testing

- Carpet cushion testing program:
  - TVOCs 1.0 mg/m²·hr
  - Formaldehyde 0.05 mg/m²·hr
  - 4-PC 0.05 mg/m²·hr
  - BHT 0.3 mg/m²·hr
- Carpet Cushion Council also undertakes emissions testing.
CRI Carpet Adhesive Testing

- Carpet adhesive testing program:
  - TVOCs 10.0 mg/m²·hr
  - Formaldehyde 0.05 mg/m²·hr
  - 2-ethyl-1-hexanol 3.0 mg/m²·hr

CRI Vacuum Cleaner Testing Program

- Soil removal
- Dust containment
- Carpet appearance retention

Carpet as a Source?

- Carpet is not a source of formaldehyde.
- Carpet does not emit VOCs at levels even remotely close to a threshold of concern.
- 4-PC emissions, if present, are low and not toxic.
- Most VOCs are offgassed within the first 96 hours after airing.
- Most carpets emit only trace amounts of a limited number of VOCs (look for the IAQ label).
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**Floor Coverings as a Sink?**

- Floor coverings and biologicals (fungi, cockroaches, dust mites etc.)?
- Floor covering maintenance?
  - Vacuuming
  - Cleaning methods

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**Fungi**

- Health problems can be caused by spores, parts of the fungal body, and fungal metabolites (mycotoxins).
- Fungi need moisture and food for growth.

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**Fungi**

- Fungi can grow on and under persistently wet carpet
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**Fungi**

- Fungi can grow on and under persistently wet VCT floors.

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**Floor Surface Biologicals**

(Black, 1995)

<table>
<thead>
<tr>
<th>Fungi/Plate</th>
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<th>April</th>
</tr>
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<tbody>
<tr>
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<td>31</td>
</tr>
<tr>
<td>Ceramic Tile</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>VCT</td>
<td>-</td>
<td>48</td>
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</tbody>
</table>

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**Microbial Growth Requirements**

- Fungi and bacteria do not feed and grow on carpet fibers or on VCT.
- Fungi do not grow on flooring and building materials when the RH is below 80% (Korpi et al., 1998).
- Regular cleaning and drying maintains flooring integrity.
• People shed ~50 million skin scales/day (~1 Kg/year).
• Mites feeds on fungus + dead skin scales.
• Mites cannot feed at humidity <70% and die at humidity <50%.
• Mite fecal pellets <20 µm.
• About 15 million Americans are allergic to dust mites, mainly feces.
• 30-40% of asthmatic children are sensitized to dust mites.
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**Mites in Florida**
(Fernandez-Caldas et al., 1990)

- Surveyed 40 homes in Tampa, FL.
- Mites present in 88% dust samples.
- Mite allergen in carpet dust not airborne.
- Mattresses averaged more than twice the mite/g dust found in carpet dust.

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**Dust Mites**

- Dust mites most common in mattresses and bedding (~1,000,000 per mattress).
- Dust mites present in upholstered chairs.
- Dust mites in carpet can easily be managed.
- Mites are killed by UV, liquid nitrogen, dilute tannic acid, acaricides (benzyl benzoate).

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**Carpet and Mites**

- Most research on mites is in Europe, where different types of carpet are used.
- Most US research has measured mites in carpet dust, not mite allergen in the air.
- Synthetic and wool carpet can have similar counts of mites in carpet dust, but airborne allergen levels are only high with wool carpet.
- Synthetic carpet better traps and holds dust, and airborne mite allergen levels are comparable to a hard floor.
Dust Mites and Asthma

- Dust mite allergen sensitization effects on asthma occur within the first 3 years and probably within the first 12 months of life.
- Sensitization requires exposure to high mite allergen levels for prolonged periods.
- Sensitization often occurs in conjunction with exposure to other allergens - cat, dog, cockroach.
- Mattresses, not carpets, pose the most significant risk for mite allergen exposure.

Floor Dust in Schools

(Dybendal et al., 1989)

- Floor dust samples tested from classrooms in 12 schools.
- No differences qualitatively or quantitatively between floor dust from carpet or linoleum.
- Mite allergen levels highest in air over smooth floors.
- School environment typically has low levels and is protective against mite allergen.

Pet Allergens

(Dybendal and Elsayed, 1992)

- About 100 millions domestic animal pets in USA (56 million cats).
- Cat allergen (feline domesticus I - Fel d 1) produced by sublingual salivary glands and hair root sebaceous glands.
- Fel d 1 can contaminate a room in 30 minutes and be detected at least 20 months after pet is removal.
- Cat allergen is very prevalent in school floor dust, and is introduced on clothing.
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**Floor Dust Removal**

- Effectiveness of vacuums is now tested.
- Use of high-efficiency cleaners (cleaning bags – 3-layer microfiltration) is important.

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**Managing Biocontaminants**

(Washington + Florida AQS Studies)

- Floor surface biologicals are similar to airborne biologicals for carpet and hard surfaces.
- Airborne biologicals track outdoor air.
- Replacing carpet does not reduce indoor airborne biologicals.
- Dust mite allergen in carpet dust is not found in the air without considerable mechanical disturbance; airborne levels are short-lived.
- Contaminants in carpet can be removed with simple maintenance.

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**Carpet and Asthma in Sweden**

(Shishoo and Bojesson, 1996)

- 1975: 40% floors
- 1992: 2% floors
Allergy and Asthma
(Jaakkola et al., 1999)

- 251 healthy infants and toddlers compared to 251 diagnosed with asthma.
- Children with PVC flooring in nurseries, bedrooms and other rooms had an 89% higher risk of asthma than those in PVC-free homes.

Emissions from Computers
(Ostman, 2000)

- When new, plastic computer monitors can emit triphenyl phosphate, an allergenic chemical that is widely used as a flame retardant, and concentrations are significant in the breathing zone, especially with new computers.

Childhood Asthma Risks
(Ball et al., 2000)

- Exposure of young children to other children at day care protects against the development of asthma later in childhood.
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Childhood asthma risks

- Asthma risks in infancy and childhood:
  - Gender (males vs. females)
  - Maternal asthma
  - Maternal smoking
  - Atopy - Hay fever, eczema
  - Ethnicity (Caucasian, African American)
  - Early respiratory infection (RSV)

- Sensitizers:
  - Molds and fungi
  - Allergens - cockroaches, cats, dogs, dust mites
  - High fat diet
  - Inactivity
  - PVC and plasticizers
  - Acetaminophen, antibiotics
  - Air pollutants (e.g. NO₂, O₃)

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Asthma Protection

- Infants are protected from asthma by:
  - No maternal smoking
  - Breast feeding
  - Larger family size
  - Early exposure to other children
  - Early respiratory illnesses (not RSV)
  - Farming lifestyle

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Effects of Floor Coverings

- Indoor air quality
- Safety (slips, trips, falls)
- Comfort (sitting surface)
- Cleaning and maintenance
- Appearance - color, softness, texture, comfort, quality.
- Acoustics - ambient, impact noises (School Sound Level Study, 1988)
Environmental Benefits

• Carpet traps dust for periodic removal.
• Carpet is recyclable.
• Carpet can be cost competitive to install, and less costly to maintain than other surfaces.

Educational Benefits

• Carpet is a safe surface –
  – less frequent and less serious trips and falls (less force) on carpet.
  – no slips on carpet.

Educational Benefits

• Carpet improves thermal conditions (insulation) and acoustic conditions (impact noise, reverberation time) in classrooms and schools.
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**Conclusion**

- Carpet can be a cost effective and beneficial floor surface for schools.

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*If you select carpet as a floor covering...*

Look for "green" and keep it clean!

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*Thank you...*  
*Questions?*