Sick Building Syndrome

DEA 350

Sick Building Syndrome

A collection of self-reported health symptoms that are experienced when in a building:

- **Irritation symptoms** (mucus membrane e.g. eye, nose and throat irritation, + skin irritation)
- **Neurotoxic symptoms** (e.g. headache, nausea, dizziness. difficulty concentrating, hoarseness)
- **Somatic symptoms** (e.g. lethargy, mental fatigue)
- **Unspecific hyperreactivity reactions** (e.g. chest tightness, difficulty breathing, runny nose, congested nose, cough)

Symptoms resolve upon leaving the building.

**Operational Definitions**

- **Problem Buildings**
  Defined by objective assessment of HVAC operation and design, and/or the presence of hazardous pollutants. There may or may not be a high prevalence of SBS complaints.

- **Sick Buildings**
  Defined by a high prevalence of subjectively assessed symptoms. There may or may not be an objectively measurable air quality and/or HVAC operation problem.

**Laboratory studies of SBS**

(Frank, 1992)

- Exposed healthy nonsmokers to clean or VOC laden air.
- Total protein and LDH in tear fluid increased with exposure to acrolein in Ss reporting eye irritation.
- 2 hours exposure to 20 $\mu$g/m$^3$ of 3 VOCs increased eye, nose and throat irritation, especially in “sensitive” Ss.
- Increased cognitive task errors in sensitive Ss with VOC exposure.

**TVOCs and SBS**

(Sundell *et al.*, 1993)

Gram-negative Bacteria, Endotoxin

and the Sick Building Syndrome

(Teeuw *et al.*, 1994)

- 19 government office buildings in the Netherlands.
- 7 buildings naturally ventilated, 11 mechanically ventilated.

Gram-negative Bacteria, Endotoxin
and the Sick Building Syndrome
(Teeuw et al., 1994)
- 19 government office buildings in the Netherlands.
- 7 buildings naturally ventilated, 11 mechanically ventilated.
- 7 mechanically ventilated buildings were 'sick'.
- 1,335 workers (~25% women, ~75% men) completed a health questionnaire.
- CO₂, VOCs, dust, positive and negative ions, temperature and RH, light, noise, airborne microorganisms and endotoxin were measured.

Gram-negative Bacteria, Endotoxin
and the Sick Building Syndrome
(Teeuw et al., 1994)
- Sixfold increase in airborne endotoxin (254 ng/m³) in "sick" buildings. Gram-negative bacteria inside ventilation system, especially in water baths/drip pans/humidifiers.
- Previous research shows:
  - Acute exposure to endotoxin at 33 ng/m³ is sufficient to detrimentally affect the forced expiratory volume in one second (FEV1; Rylander et al., 1988)
  - Lower concentrations of endotoxin (9 ng/m³) provokes symptoms with prolonged exposure (Castellan et al., 1987)
  - Endotoxin levels between 30 and 350 ng/m³ provoke influenza-like symptoms (chills, muscle aches, fatigue, headache, dry cough, clogged nose, wheeze, and chest tightness) in pig farmers (Heederik et al., 1992)

Dust and the Sick Building Syndrome
(Gyntelberg et al., 1994)
- 12 Town Halls in the Copenhagen area.
- 870 workers studied (584 women, 286 men) who completed a health questionnaire.
- Settled dust samples collected from floor and analyzed for:
  - inorganic particles
  - organic particles
  - human source fragments (hair, nails, skin)
  - fibers - paper, glass, mineral, organic
  - macromolecular organic dust (MOD)
  - bacteria, endotoxin, fungi
  - dust mite allergen
- SBS correlated with MOD

Oil Residues in Ventilation Ducts
(Pasanen et al., 1995)
- Tested duct dust for residues of 2 types of processing oils used to decrease friction during manufacture of circular air ducts:
  - mineral oil - 70% oil + 30% additional components
  - vegetable oil - 70% turnip rape oil + 25% additional components + 5% water
- Interior surface of new ducts has a thin oil layer that promotes dust accumulation and prevents effective cleaning.
- After 10 months 60% of the initial mineral oil residue and 79% of the initial vegetable oil residue remained.
- Processing oil residues can bind water at high relative humidities and provide sufficient
nutrients for fungal growth.

- Odor emissions are about 3 times higher for vegetable oil residues and these increase over time (at least up to 250 days), whereas odors from mineral oils decrease over time.

**Oil Residues in Ventilation Ducts**
(Pasanen et al., 1995)

**Textile Wall Materials and SBS**
(Jaakkola et al., 1994)

- Studied the prevalence of SBS symptoms for the past 7 days among 400 workers (264 men; 136 women) in 2 identical mechanically ventilated buildings, 1 building with soft textile wall materials, 1 building with hard wall surfaces.
- Each building was constructed in 1974, was 35,000 m$^3$ and had operable windows as well as central mechanical ventilation systems.
- Workers divided into 'high' or 'low' textile exposed groups, or an unexposed 'reference' group. All groups had similar demographic profiles.
- Regression analyses showed a significant dose-response relationship for eye, nose and throat symptoms for the exposed vs. reference groups (high - OR = 2.46; low - OR = 1.82).
- No other symptoms associated with textile wall materials.

**Gender and SBS symptoms** (Hedge et al., 1996)

**Migraine and SBS symptoms** (Hedge et al., 1996)

**Spectacles and SBS**
(Hedge et al., 1996)

**Allergies and SBS**
(Hedge et al., 1996)

**Job Stress and SBS**
(Hedge et al., 1996)

**Job Dissatisfaction and SBS**
(Hedge et al., 1996)

**Computer Use and SBS**
(Hedge et al., 1996)

**Weekly Indoor Climate Ratings**
(Hedge et al., 1997)

**Weekly SBS complaints** (Hedge et al., 1997)

**PIAQ and SBS (PSI15)**
(Hedge & Erickson, 1998)

**Office SBS and IAQ Complaints**
(Reynolds & Hedge, 1999)
CFD Isosurface for HCHO
(Reynolds & Hedge, 1999)

CFD Isosurface and Temperature
(Reynolds & Hedge, 1999)

CFD Isosurface for CO$_2$ > 675ppm
(Reynolds & Hedge, 1999)

CFD Isosurface for Temperature and CO$_2$
(Reynolds & Hedge, 1999)

Human Abilities to Detect Air Pollutants

<table>
<thead>
<tr>
<th>POLLUTANTS</th>
<th>DIRECT SENSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos, fibers, particulates</td>
<td>None</td>
</tr>
<tr>
<td>Radon, radiation</td>
<td>None</td>
</tr>
<tr>
<td>Carbon monoxide, dioxide</td>
<td>None</td>
</tr>
<tr>
<td>Viruses/ Bacteria</td>
<td>None</td>
</tr>
<tr>
<td>Fungal spores</td>
<td>None</td>
</tr>
<tr>
<td>Endotoxins, mycotoxins</td>
<td>None</td>
</tr>
<tr>
<td>Allergens</td>
<td>None</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>None</td>
</tr>
<tr>
<td>Sulfur/nitrogen oxides</td>
<td>Odor/irritation</td>
</tr>
<tr>
<td>Ozone</td>
<td>Odor/irritation</td>
</tr>
<tr>
<td>VOCs</td>
<td>Odor/irritation</td>
</tr>
<tr>
<td>ETS</td>
<td>Vision/odor/irritation</td>
</tr>
<tr>
<td>Temperature, air movement</td>
<td>Cutaneous</td>
</tr>
</tbody>
</table>

Cacosmia

Cacosmia is an “altered sense of smell, accompanied by a tendency to feel ill (e.g. nausea, headache, dizziness) from the odor of chemicals at low levels that have no effect on normals.”
(Bell et al., Archives of Environmental Health, 47, 1993, p.316)

Cacosmia and Perceived Climate Conditions
(Hedge et al., 1996)

Cacosmia and SBS
(Hedge et al., 1996)

Cacosmia and SBS (PSI15)
(Hedge & Erickson, 1998)

Nonenvironmental variables affecting the number of SBS symptoms per person
(Hedge et al., 1994, 4,373 workers)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>P</th>
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<tbody>
<tr>
<td>Intercept Female</td>
<td>1.69 ± 0.38</td>
<td>0.0001</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>Male</td>
<td>1.04 ± 0.39</td>
<td></td>
</tr>
<tr>
<td>VDT hours</td>
<td>0.11 ± 0.02</td>
<td>0.0001</td>
</tr>
<tr>
<td>Job Stress</td>
<td>0.61 ± 0.06</td>
<td>0.0001</td>
</tr>
<tr>
<td>Job Dissatisfaction</td>
<td>0.42 ± 0.05</td>
<td>0.0001</td>
</tr>
<tr>
<td>Perceived IAQ</td>
<td>0.63 ± 0.02</td>
<td>0.0000</td>
</tr>
<tr>
<td>Age</td>
<td>-0.01 ± 0.00</td>
<td>0.0169</td>
</tr>
<tr>
<td># Allergies</td>
<td>0.49 ± 0.07</td>
<td>0.0001</td>
</tr>
<tr>
<td>Migraine</td>
<td>0.63 ± 0.14</td>
<td>0.0001</td>
</tr>
<tr>
<td>Eyeware</td>
<td>0.25 ± 0.10</td>
<td>0.0098</td>
</tr>
<tr>
<td>Smoker</td>
<td>0.24 ± 0.11</td>
<td>0.0321</td>
</tr>
</tbody>
</table>

Swedish National Office Illness Project (Ericksson et al., 1996, 4,393 workers)

- Building factors
  - Condensation
- Personal factors
  - Gender
  - Age (weak)
  - Marital status (childless)
  - Workload stress
  - Paper index
  - Asthma, allergic rhinitis
  - VDU work (>1 hr/day)

European Audit Project (56 buildings) (Bluyssen et al., 1996)

Risk indicators for SBS
- Building factors
  - Heavy traffic
  - Humidifying or cooling systems
  - Low outdoor air supply
- Personal factors
  - Gender
  - Job (stress)
  - Eczema, allergic rhinitis
  - VDU work
- Exposures
  - Low TVOCs
  - Low RH (skin symptoms)
  - Noise

SBS :Regression Analysis (Hedge & Erickson, 1998)
Mean Building Environment Ratings (Hedge & Erickson, 1999)
Mean SBS ratings  
(Hedge & Erickson, 1999)  
MS6 and SBS (PSI15)  
(Hedge & Erickson, 1999)  
Psychological Influences on the SBS

- Sensation and perception.
- Attention and cognition (schema, attitudes, beliefs).
- Classical and operant conditioning.
- Arousal, stress, work demands.
- Control and coping behaviors.
- Anxiety, neuroses, aversions, phobias.
- Attribution, learned helplessness, illness behavior.
- Group dynamics, mass hysteria.
- Clinical abnormality, “hypersensitivities”.
- Management styles, labor relations, hidden agendas.
- Organizational and political climate.

Managing a SBS Problem  
(Getting your building in SHAPE)

- Sympathy  empathic, receptive, genuine, caring.
- Honesty  open, sharing, informing.
- Action  do something, be visible.
- Participation  involve occupants, consult, discuss.
- Evaluation  get feedback on interventions.

Planning for Problems

- State the alternative strategies available.
- List advantages & disadvantages of each strategy.
- State costs of each option.
- Allocate responsibilities, identify 'experts'.
- Plan to deal with the media.
- Write an IEQ plan.

Written IEQ Plans

- Description of building systems with schematics for major systems and areas served.
- Daily operation and management information.
- Maintenance program, procedures, schedule.
- Visual inspection checklist.
- Archival records - as-built documents, commissioning reports, maintenance logs, training documents etc.
- Employee records - prevalence, incidence and nature of complaints, dates, remedial action, outcome.
Clear allocation of responsibilities.

Managing an Incident

- Seek the best independent experts.
- Implement one or more of the planned strategies.
- Identify and execute action items.
- Evaluate the results if things go as proposed.
- Communicate with concerned parties.
- Manage the information flow.