Health Risks of Tightly Sealed Buildings

When Green Is Not Always Good

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Presentation outline

- Disclaimers (energy-saving methods that *don't* incur health risks)
- Background on indoor environmental health
- Mechanisms of increased exposure in tightly sealed homes
- Health effects
- Costs of illness
- Potential solutions

Energy-saving methods that *don't* incur health risks

- In homes:
  - Solar energy
  - Motion-controlled lighting
  - Fluorescent lighting
  - Energy-efficient appliances
  - Behavioral changes (turning off lights, computers, etc.)
- Focus is on tightly sealed homes

The public health risk: Indoor environmental hazards

Chemical

- Environmental tobacco smoke
- Radon
- Lead
- Nitrogen & sulfur oxides
- Carbon monoxide (CO)
- Particulate matter (PM)
- Volatile organic compounds
- Pesticides
- Formaldehyde
- Platicizers (e.g., phthalates)

Biological

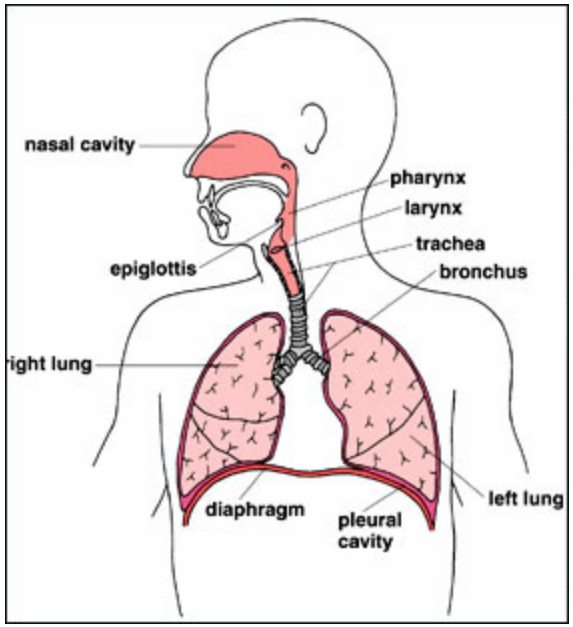
- Animals (pets, farm animals, pests)
- Cockroach
- House dust mite (HDM)
- Mold / fungi
- Endotoxins
- Infectious agents (viruses, bacteria)
- Pollen

Corresponding health effects

- <u>Respiratory</u>
  - Asthma (development, exacerbation)
  - Upper & lower respiratory illnesses
  - Cough & wheeze
  - Hypersensitivity pneumonitis (lung inflammation caused by body's immune reaction to airborne particles)

- <u>Psychological</u>
  - "Sick building syndrome"
  - "Presenteeism" – at work but out of it
  - Depression

- <u>Cancer</u>
  - Leukemia (benzene)
  - Mesothelioma (asbestos)
  - Lung cancer (ETS, radon)



Asthma rates increasing

- 75% increase in asthma rates in U.S. from 1980-1994
- 160% increase in same time in children < 4 yrs (IOM 2000)
- Change too dramatic to be due to genetics
- → Must be due to environmental factors
- Evidence points to indoor environmental quality problems

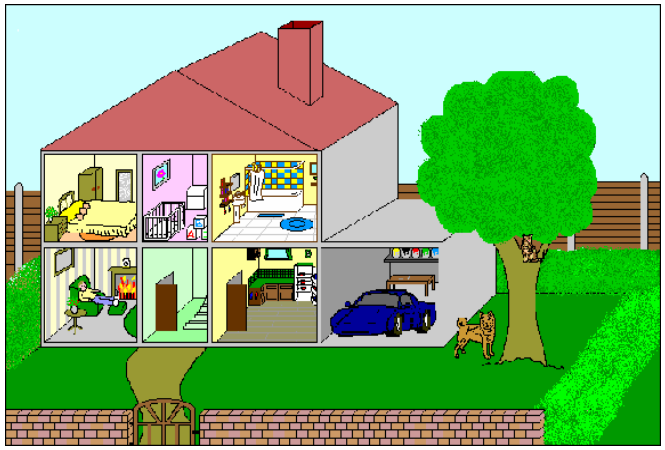
Example: Link between asthma exacerbation & indoor pollutants (IOM 2000)

"Indoor exposures may significantly influence the disease course of asthma." (IOM 2000)

	Indoor biological / chemical agent
Sufficient evidence of causal relationship	Cat, cockroach, ETS, house dust mite
Sufficient evidence of association	Dog, fungi or molds, nitrogen oxides, rhinovirus
Suggestive evidence of association	Birds, *Chlamydia pneumoniae*, ETS, formaldehyde, *Mycoplasma pneumoniae*, RSV

Statistics on exposure

- Modern societies: 90% time spent indoors
  - 67% in homes
- Human indoor exposures function of:
  - Building materials, appliance types, lifestyles, behaviors, animals
- Regional climate affects exposures
  - HDM, cockroaches: temperate & humid regions
  - Mold, bacteria & viruses ubiquitous (IOM 2000)



- U.S. households (IOM 2000)
  - 50% use gas appliances (CO, NO_2 exposure)
  - 84% use pesticides
  - 27%, 31%, 5% have cats, dogs, birds respectively
  - Every house has dust mite: range 0.2-100 ng/m^3

Vulnerable subpopulations

- Children
  - Pound for pound: breathe in twice as much air, eat 3-4 times as much food, have 3 times rate of skin absorption compared with adults (Bearer 1995)
  - Close to ground; explore everywhere; eat everything
  - Cost of lifetime of disease enormous
- Low-income households
  - Most likely to have homes with severe physical problems
  - Least likely to have means (information, money) to remediate problems
  - Low income linked with asthma mortality, morbidity (IOM 2000)

Risk characterization of indoor environmental hazards

- Weight of evidence: indoor environmental contaminants pose significant public health risks
- Health problems getting worse in recent years

- → **How can tightly sealed buildings exacerbate these risks?**

How tightly sealed homes increase health risk

- Trap moisture
- Reduce air exchange rate (AER) with outdoors
- Increase effects associated with HVAC systems

Trap moisture

- Possibly most important problem regarding asthma increases in recent years
- Moisture promotes:
  - Mold
  - Bacteria
  - House dust mite
  - Cockroach
  - Off-gassing of VOCs & other chemicals in home

Reduce air exchange rate with outdoors

- Contaminants generated indoors stay indoors
  - Environmental tobacco smoke (ETS)
  - NO_x
  - CO_x
  - Animal allergens
- Contaminants from outside that leak in stay in
  - Radon
- Reduced AER also slows escape of water vapor
  - Contributes to moisture problem
  - → Increases all contaminants listed previously

Increase effects associated with HVAC systems

- HVAC systems themselves do not increase respiratory health risk
  - Improper maintenance of them does
- Heating
  - Humid indoor air contacts cold walls or windows → condensation & moisture problems
- Air conditioning
  - > 15 studies: strong link between AC and numerous respiratory symptoms
  - Microbes thrive in AC systems (fungi, bacteria)

Health effects exacerbated by tightly sealed buildings

- Asthma (microbes, animal allergens, house dust mite, cockroach, ETS)
- Upper & lower respiratory symptoms (cough, wheeze, etc.)
- Chronic obstructive pulmonary disease (COPD)
- “Sick building syndrome”
- Infection in immunocompromised individuals (fungi & bacteria)
- Lung cancer (ETS, radon)

Costs of unhealthy indoor environments in the United States ($US 2005)

Annual asthma costs, direct medical + work losses (Weiss et al. 2000) 15 million cases of asthma	**$12 billion**
Annual worker losses from all respiratory symptoms (Mendell et al. 2002)	**$100 billion** ($90B health care; $10B lost productivity)
Annual health insurance cost per employee for: asthma, allergies, back pain, colds, throat & sinus conditions, “sick building syndrome” (Loftness 2005)	**$745** (agrees roughly with Mendell et al. estimate)
Annual cost of environmentally-attributable childhood diseases: lead poisoning, asthma, cancer (Landrigan et al. 2002)	**$64 billion**

Indirect costs: Individuals' valuation of respiratory symptoms

- $7-280 per additional symptom day avoided
  - contingent valuation [CV], Loehman et al. 1979
- $65-341 per additional symptom day avoided
  - CV, Berger et al. 1987
- $170 avg for 1-day reduction in bad-asthma days
  - CV, Rowe & Chestnut 1983

  - *Source: Health Canada EIN 0601 1 (2001)*

Potential solutions

- How can tightly sealed buildings be both green and good?
  - Improved building design
  - Use of moisture-resistant materials
  - Dehumidifiers
  - Behavioral changes to reduce moisture generation
  - Window opening (as weather permits)
  - Frequent cleaning of HVAC systems
  - Moderation in use of heating and air conditioning

Summary

- Indoor environments contain multiple agents that can cause adverse health effects
- Asthma, associated with indoor air, increasing in recent years
  - In part due to more tightly-sealed buildings
- Tightly-sealed buildings contribute to problems in 3 main ways
  - Trap moisture
  - Reduce AER
  - Exacerbate HVAC problems
- Societal costs of indoor air illnesses enormous
- Solutions lie in improved building design & maintenance, and behavioral modifications

- **Mini-monograph on indoor air and health published in *Environmental Health Perspectives*** (June 2007)

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