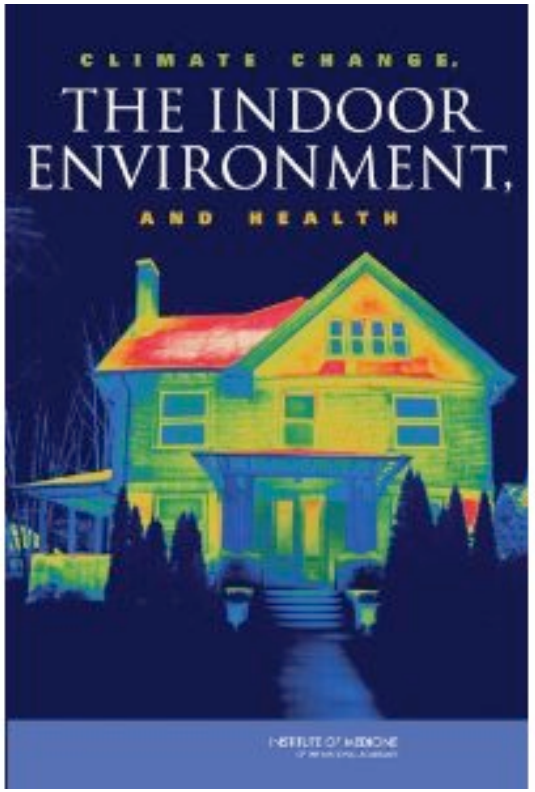
BEARS | Berkeley Education Alliance for Research in Singapore

SinBerBEST | Singapore-Berkeley Building Efficiency and Sustainability in the Tropics

Climate Change, the Indoor Environment, and Health



William W Nazaroff
University of California, Berkeley
SinBerBEST Annual Meeting
9 January 2013

NANYANG TECHNOLOGICAL UNIVERSITY

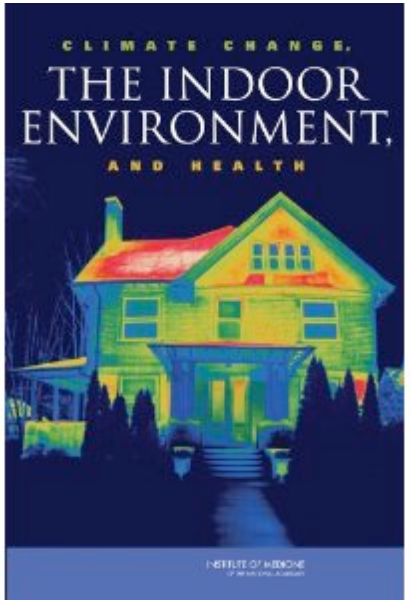
NUS National University of Singapore

Study by the US Institute of Medicine

Commissioned by the USEPA with this charge:
Summarize the current state of scientific understanding with respect to the effects of climate change on indoor air and public health.

Study Committee

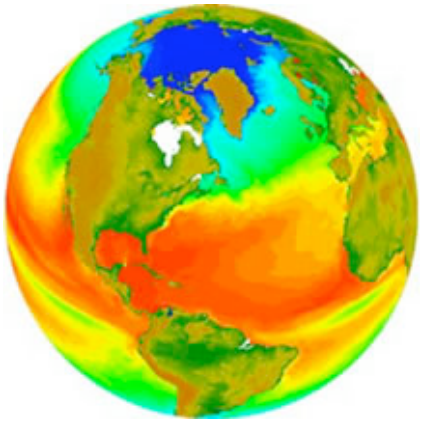
John D Spengler, Chair, Harvard School of Public Health
John L Adgate, University of Colorado
Antonio J Busalacchi, Jr, University of Maryland
Ginger L Chew, Centers for Disease Control
Andrew Haines, London School of Hygiene & Tropical Medicine
Steven M Holland, National Institutes of Health
Vivian E Loftness, Carnegie-Mellon University
Linda A McCauley, Emory University
William W Nazaroff, University of California, Berkeley
Eileen Storey, National Institute for Occupational Safety and Health
David A Butler, Study Director

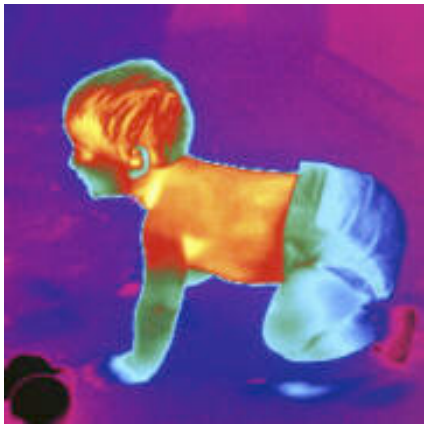


Full report (2011) can be read or purchased at
http://books.nap.edu/openbook.php?record_id=13115

Key findings: climate change, IEQ and health

- Poor indoor environmental quality (IEQ) is creating health problems today and impairs the ability of occupants to work and learn.
- Climate change may make existing IEQ worse and may also introduce new problems.
- Opportunities exist to improve public health while mitigating or adapting to alterations in IEQ induced by climate change.



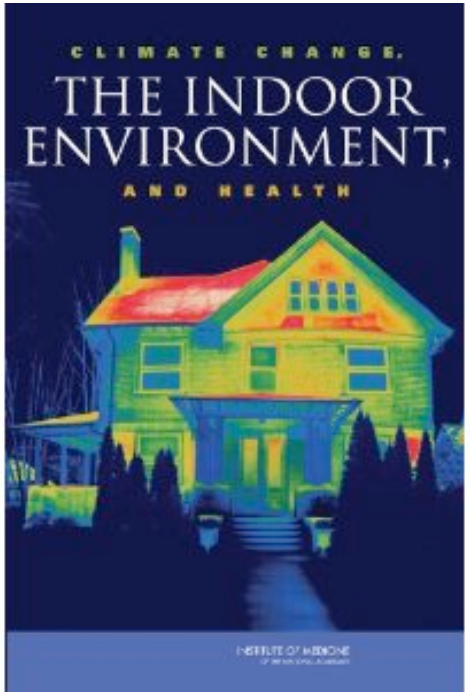


CC, IEQ and Health: Examples of concerns

- Altered frequency and severity of adverse outdoor conditions that affect the indoor environment
- Outdoor conditions becoming more hospitable to pests, infectious agents, and disease vectors that can penetrate the indoor environment.
- Mitigation and adaptation measures and changes in occupant behavior that cause or exacerbate harmful indoor environmental conditions.

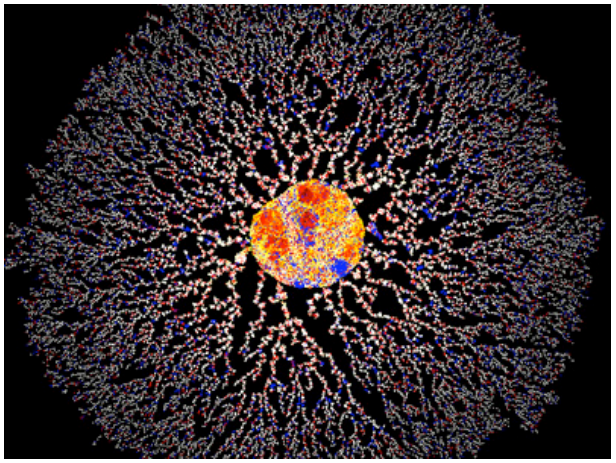
Report scope and structure

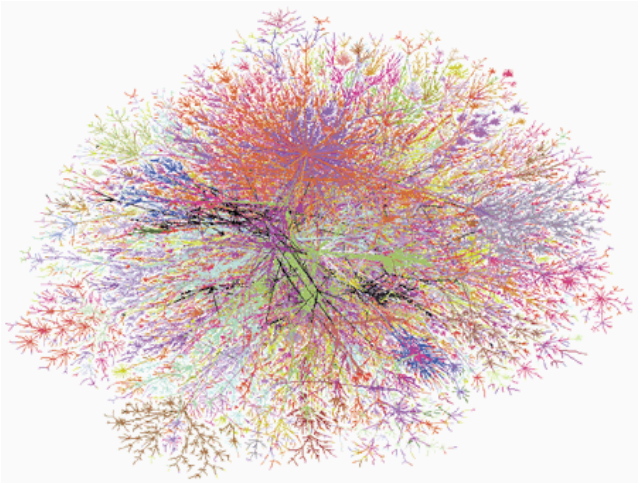
1. Introduction
2. Background
3. Government and private sector involvement in climate change, indoor environment, and health issues
4. Air quality
5. Dampness, moisture, and flooding
6. Infectious agents and pests
7. Thermal stress
8. Building ventilation, weatherization, and energy use
9. Key findings, guiding principles, and priority issues for action



Climate change, the indoor environment & health

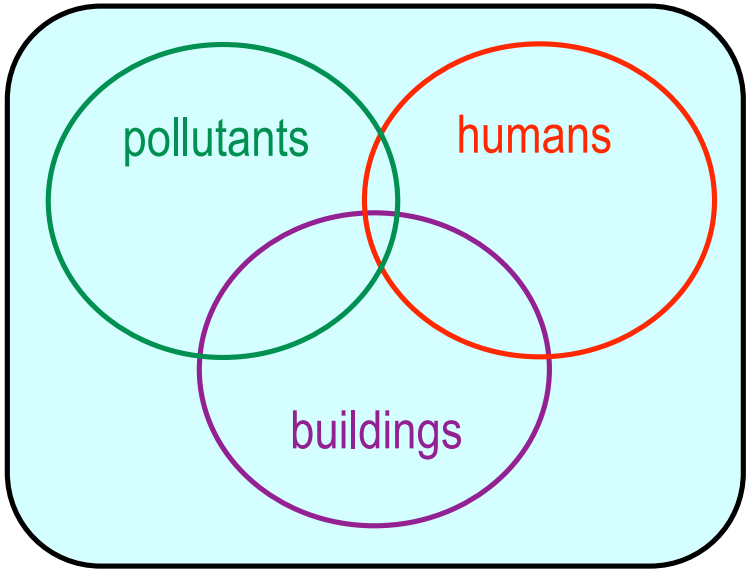
- Numerous and diverse elements influence outcomes
- Interconnections are complex
  - feedback loops
  - interweaving
    - > natural processes
    - > technology
    - > individual behavior
    - > social systems
- Challenges derive from systemic attributes rather than individual elements





Three factors classes govern indoor air quality

- Three classes of factors govern IAQ
  - pollutant attributes
  - building characteristics
  - human behavior.
- We have little direct evidence about climate change impacts.
- However, information is available on the factors that influence indoor concentrations of health-relevant pollutants and how these might shift as a consequence of climate change.



Material balances govern pollutant concentrations

- Sources and removal combine to determine concentrations.
- Concentrations + occupancy produce exposures.
- Excessive exposures confer risk.
- Climate change can affect the system in numerous particular ways.

$$C \sim \frac{pQC_{out} + E}{Q + kV}$$

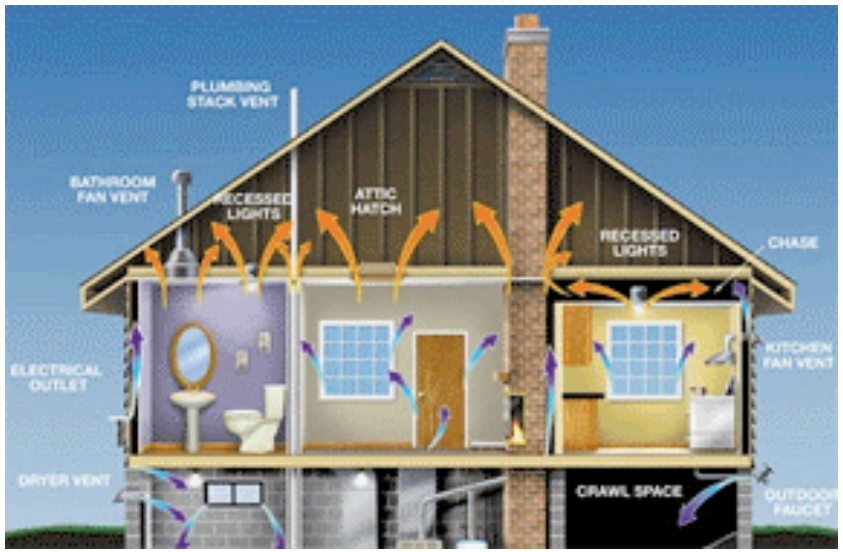
← sources

← removal

C — pollutant concentration; p — penetration factor; C_{out} — outdoor pollutant concentration; E — emission rate from indoor sources; Q — ventilation rate; k — loss-rate coefficient (excl. ventilation); V — interior volume.

Human responses influence outcomes

- Indirect shifts in IEQ, mediated by human responses to climate change.
- Example: increased use of air conditioning and energy-savings mitigation measures could lead to systematically lower ventilation rates causing increased exposures to pollutants emitted indoors.



Risks from responding to climate emergencies

- Reactions to weather emergencies pose IAQ risks to public-health.
- Example: potential for poisoning from exposure to CO emitted from emergency electricity generators.
- Emergencies may increase in frequency if climate change results in more frequent or more severe storms.

Importance of well-informed individual action

- Individual action can profoundly influence IAQ in individual buildings.
- There is a public interest in seeing that the system for establishing and maintaining good IAQ works well.
- Negligent or ill-informed behavior by individuals can cause serious harm.

Combustion dominates as pollution source

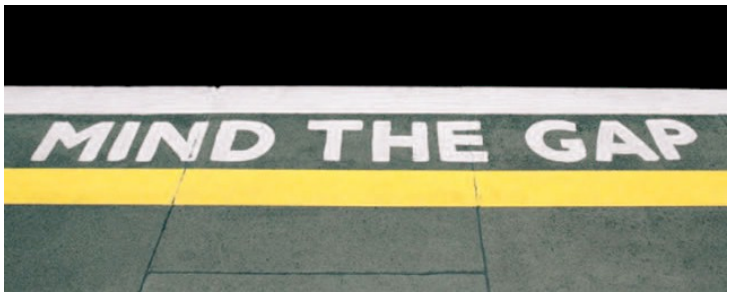
- Combustion is a major source of both outdoor and indoor air pollution
- Regarding health risks, combustion is the most important source of indoor air pollutants.
- Important issues are associated cooking, smoking, heating, and (potentially) use of candles, incense, etc.
- Other important pollutants from indoor sources: radon, VOCs and SVOCs.

Indoor concerns from outdoor pollution

- Main pollutants of concern are particulate matter (PM) and ozone.
- PM concerns that may be exacerbated by climate change include increases in smoke from wild-land fires, pollen, and windblown dust.

Large gaps: Knowledge and practice

- Large gap between what is known about public health consequences of IEQ and what *should* be known.
- The gap between what is known and what is done to address the problems may be even larger.
- One risk associated with climate change is that the gap between what is known and what is done will grow and will have adverse consequences for public health.



Addressing diversity across populations

- It is important to understand and account for population diversity:
  - variable susceptibility to the effects of exposure to degraded IEQ;
  - variability in the knowledge and resources with which to take effective action in response to changing conditions.

Addressing diversity across buildings

- It is important to take account of the different issues of concern and appropriate responses for the many different building types.

Importance of ensuring adequate ventilation

- Efforts to save energy by improving building performance need to be cautious with respect to changing building ventilation rates.
- Two driving forces are apparent:
  a. As a mitigation measure, efforts to save energy in buildings are gaining momentum.
  b. Rising temperatures during warm seasons ⇒ progressive shift to air conditioning and away from cooling by means of open windows.
- Lower ventilation rates provide enhanced protection against outdoor pollutants, such as PM.
- But reduced ventilation rates cause concentrations of pollutants that originate primarily from indoor sources to increase.

Importance of limiting indoor emissions

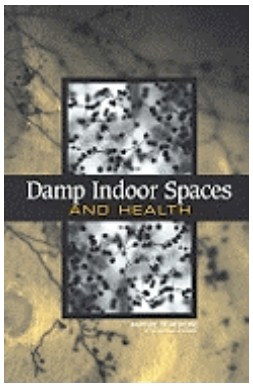
- Attention is warranted to limit emissions from indoor sources.
- Variability in emissions is usually the main determinant of whether indoor air-pollutant levels from indoor sources are excessive.
- Several potential concerns deserve attention, such as:
  - CO from emergency generators
  - emissions from cooking
  - emissions from smoking
  - VOCs and SVOCs from various indoor sources
- Special attention is needed to ensure that life-cycle impact assessments aimed at improving the environmental performance of buildings take proper account of the disproportionately large effects that emissions from indoor materials and processes can have on IAQ and public health.

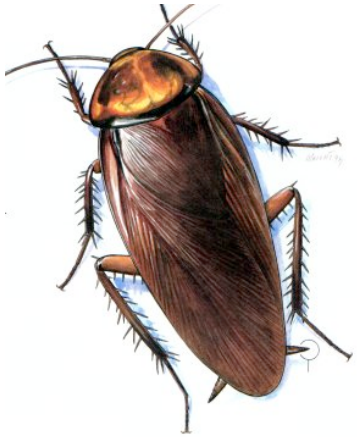
Protecting against pollutants of outdoor origin

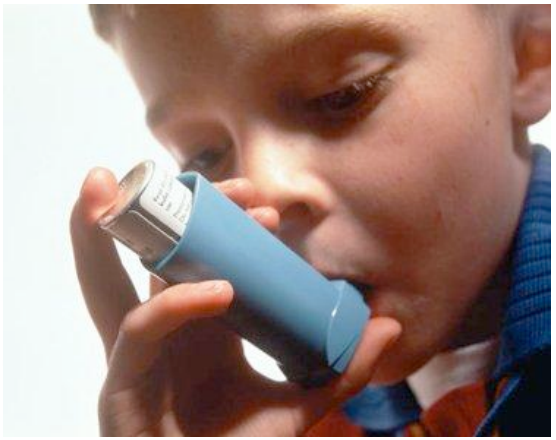
- Need better understanding of the effectiveness of indoor environments as shelters against pollutants of outdoor origin.
- Studies on climate change impacts on air pollution have focused on PM2.5 and O_3. Good regulatory and technologic systems are striving to reduce emissions from anthropogenic sources. Momentum should yield continued improvements in reducing anthropogenic emissions.
- Greater concern would apply to pollutants that lie outside the regulatory structure, such as smoke from wildfires, pollen from weeds, and windblown dust.
- Indoor environments will be used as imperfect shelters that could be improved with proper attention and a commitment of appropriate resources.

Dampness, moisture and flooding

- Excessive dampness is a determinant of several potentially problematic exposures. Damp indoor environments favor house dust mites and the growth of mold and other microbial agents, standing water supports cockroach and rodent infestations, and excessive moisture may initiate or enhance chemical emissions from building materials and furnishings.
- Damp indoor spaces are associated with initiation or exacerbation of a number of respiratory ailments.







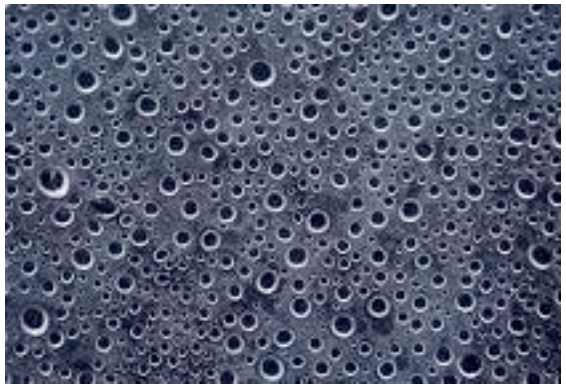
Risks from flooding

- Extreme weather and flooding events that penetrate buildings — which may become more frequent or severe in the future — increase the number of people at risk for health conditions related to standing water, wet building materials, and sustained high indoor humidity.

Risks from dampness in a changing climate

- Dampness problems in buildings are difficult to anticipate. The information needed to minimize the risk of their occurrence or their severity is available but is not being consistently applied.
- Current buildings and building design, construction, operation, and maintenance practices may not be appropriate for managing indoor dampness or flooding problems due to outdoor environmental conditions that could result from climate change.





Recommendations to USEPA: Guiding principles

- Prioritize consideration of health effects into research, policy, programs, and regulatory agendas that address climate change and buildings.
- Make the prevention of adverse exposures a primary goal when designing and implementing climate change adaptation and mitigation strategies.
- Collect data to make better-informed decisions in the future.

Recommendation to USEPA: Specific themes

- Identify and protect populations at risk.
- Develop or refine protocols and standards for material emissions.
- Protect and enhance IEQ in weatherization programs.
- Revise building codes for regionally appropriate climate readiness.
- Develop model standards for building ventilation.
- Establish a public health surveillance system for IEQ and health.
- Educate the public on climate-change IEQ and health.
- Regularly evaluate effectiveness of actions; improve as needed.
- Coordinate action across the US federal government.