

# Effects of Acid Rain on Human Health

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# 1997 Canadian Acid Rain Assessment

- Volume 5: The Effects on Human Health
  - Included studies up to 1995
  - Investigated direct and indirect health effects of  $\text{SO}_2$ ,  $\text{SO}_4^{2-}$ , PM and  $\text{H}^+$
  - Indicated future research directions
  - General conclusions:
    - Inconsistency observed in human clinical and animal studies at low levels
    - Coherent relationship between ambient particle concentrations and human mortality and morbidity, but difficulty to dissociate effects of acid aerosols from effects of PM



# 2004 Canadian Acid Rain Assessment

- Chapter 9: The Effects of Acid Rain on Human Health
  - Includes studies 1995 - 2003
  - Investigates direct health effects of  $\text{SO}_4^{2-}$  and  $\text{H}^+$
  - Does not include studies on PM and  $\text{SO}_2$ 
    - Since last assessment in 1997, new risk management program put in place to address PM and its precursors, including  $\text{SO}_2$  (Canada-Wide Standards)



# Acid Rain in Health Studies

- What is really measured:
  - Ambient concentrations of air pollutants contributing to acid rain deposition
    - Particle acidity (measured as  $H^+$  or  $H_2SO_4$  equivalent)
    - $SO_4^{2-}$
    - Acid gases/vapours (organic and/or inorganic)
    - Acid fog
    - ...



# Health Studies

- Types of studies reviewed:
  - Toxicological studies
  - Clinical studies
  - Epidemiological studies



# Toxicological Studies



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# Toxicological Studies

- Animal species studied:
  - Rats, mice, rabbits, guinea pigs
- Timeframes of exposure:
  - Ranged from single exposures of a few hours to exposures of up to 2 years
- Different acid species studied
- Different mixtures of acids with:
  - Ozone, carbon particles, nitrogen dioxide...

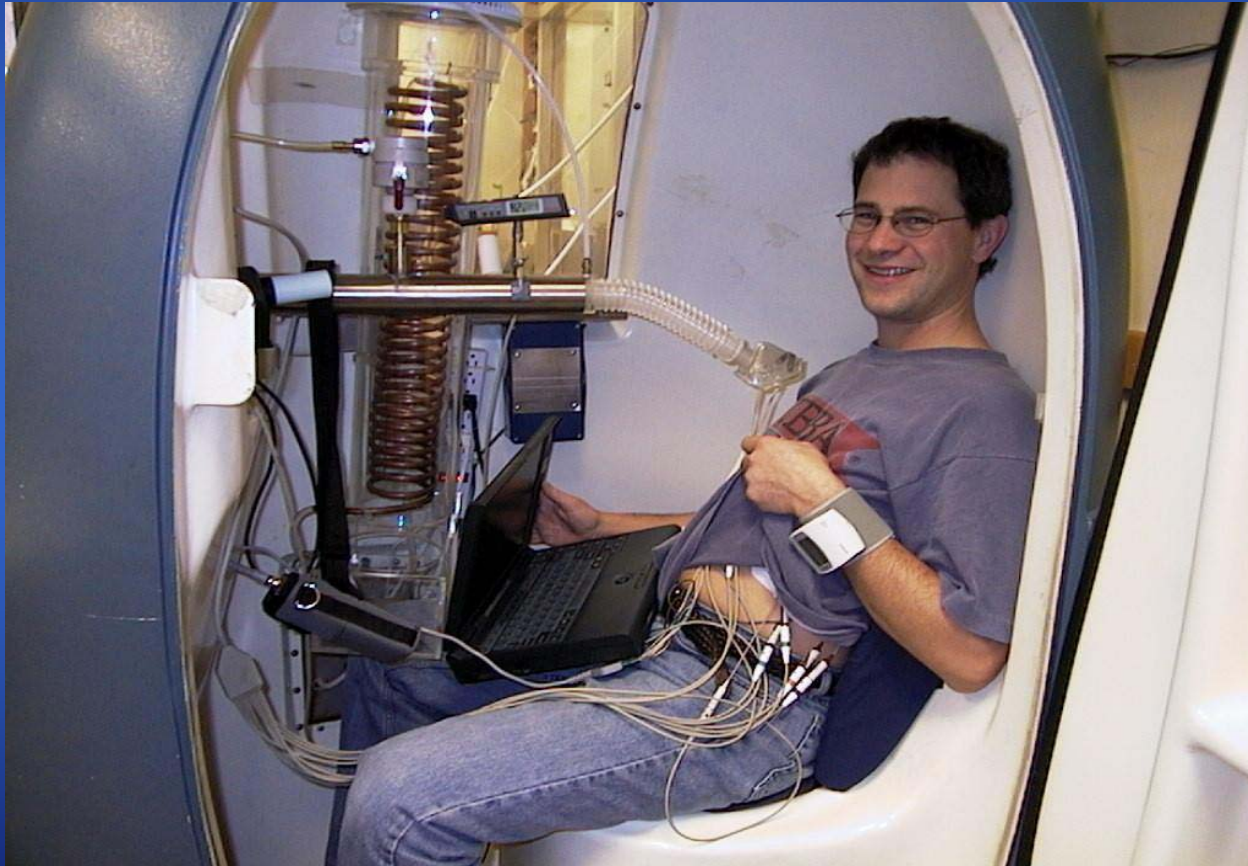


# Key Findings

- Toxicological studies (15)
  - Concentrations studied close to what can be found in Eastern Canada
  - Effects on defence mechanisms of animals
  - Exposure to mixtures of pollutants containing acids: effects decreased or increased (with no obvious consistency) when compared to effects of exposure to individual pollutants, depending on:
    - Pollutants studied
    - Concentrations and types of pollutants in mixtures
    - Effects studied



# Clinical Studies



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# Clinical Studies

- Few studies (5)
- Volunteers:
  - Healthy or asthmatic/allergic
  - Adults or children
  - With or without exercise
- Exposure to acid aerosols alone or co-exposure with ozone or pollen allergen



# Key Findings

- Clinical studies:
  - Stronger effects (respiratory symptoms and lung function) in people with asthma or allergy after exposure to:
    - Acids alone
    - Acid and ozone one after the other
    - Acid and pollen allergen one after the other
  - Levels of pollutants studied usually higher than levels measured in Canadian cities



# Epidemiological Studies



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# Epidemiological Studies (1)

- 38 studies published
- Various ways to measure acidity:
  - $\text{SO}_4^{2-}$
  - Particle acidity (measured as  $\text{H}^+$  or  $\text{H}_2\text{SO}_4$  equivalent)
  - Inorganic and organic gases/vapours (California studies)
  - Fog Acidity (Japan studies)



# Epidemiological studies (2)

- Impossible to separate health effects from exposure to acidity and to other pollutants such as PM, NO<sub>2</sub> or O<sub>3</sub>
- Effects of acid generally weaker when other pollutants taken in consideration in statistical analyses

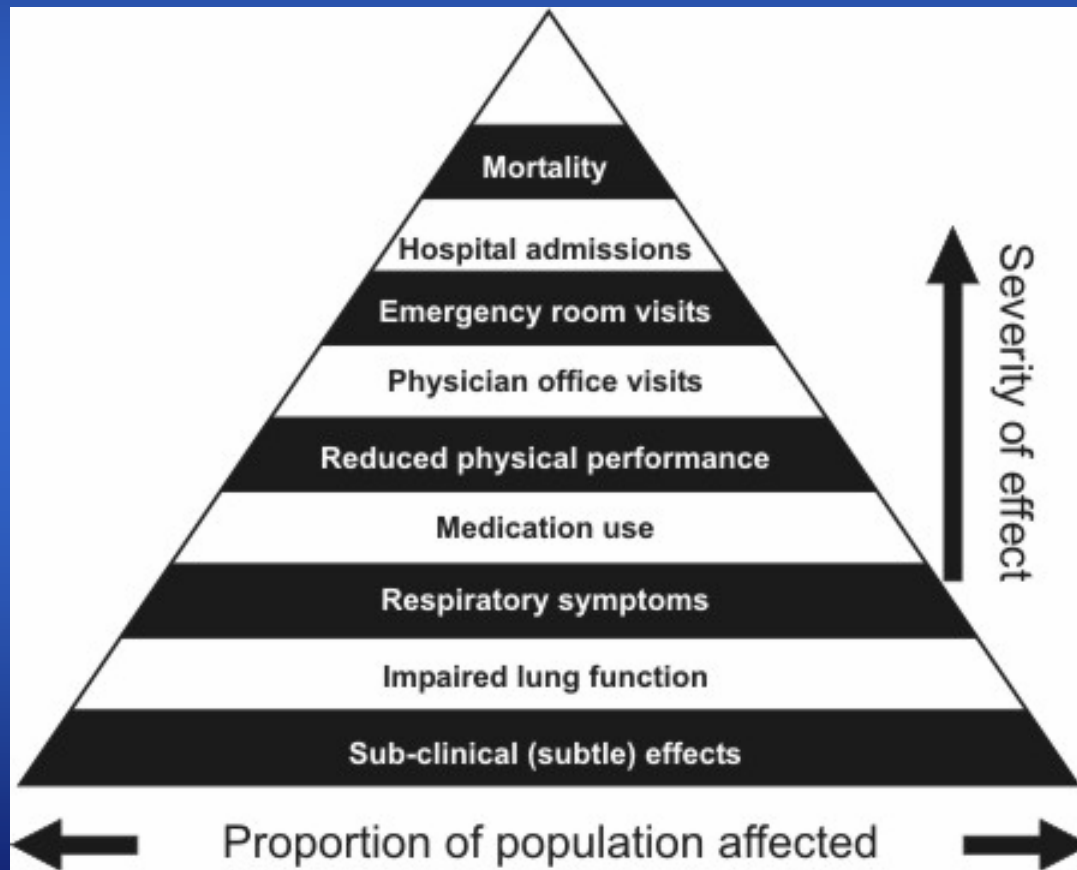


# Key Findings

- Epidemiological studies:
  - Small but significant associations between aerosol acidity and:
    - Respiratory symptoms; Impaired lung function
    - Hospital admissions, ERVs, premature mortality
  - Susceptible subgroups: children, asthmatics, people with cardio-respiratory diseases
    - Targeted in panel studies
  - Difficulty to attribute effects to specific pollutants
- Stronger study design: California study
  - Showed effects on lung function growth in children
  - Signal stable in statistical analysis with other pollutants
  - Impossible to separate from effects of other pollutants (NO<sub>2</sub>)



# Health Effects of Air Pollution



# Conclusions

- Toxicological studies
  - Effects on defence mechanisms
- Clinical studies
  - Respiratory effects in people with asthma/allergies
- Epidemiological studies
  - Various health effects
  - Impossible to separate from effects of PM



# Policy Implications

- Canada-Wide Standards for PM
- Epidemiological studies
  - Uncertain characterization of acid
- Equivocal evidence of severe health effects
- More certain for less severe health effects
  - lung function, respiratory symptoms

