

# Regulating indoor air pollution

Kirk R. Smith  
UC Berkeley

- Why would you want to do it?
- Why not just depend on regulating outdoor air pollution?
- How might it be done?

# PARACELSUS

1493-1541

*“Father of Toxicology  
and Environmental  
Health”*



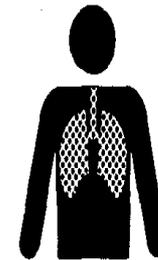
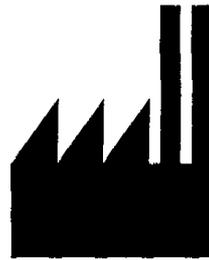
# Paracelsus

- “Poison is in everything, and no thing is without poison. The dosage makes it either a poison or a remedy.”
- Usually shortened to

“The Dose Makes the Poison”

In environmental health, ‘dose makes the poison’ is commonly elaborated as  
The Environmental Pathway:

SOURCE → EMISSIONS → CONCENTRATION → EXPOSURE → DOSE → HEALTH EFFECTS



# Exposure

Indicates the degree to which the pollution actually reaches the breathing zone of people. It depends on the amount of pollution, the number of people, and the total time.

## Wallace's Maxim

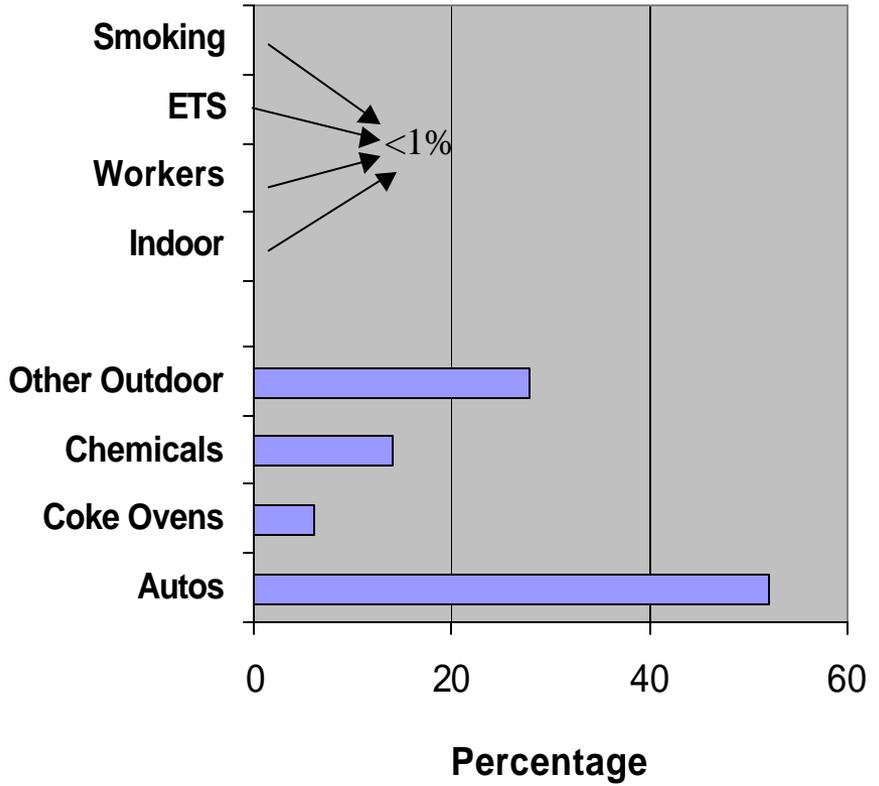
To obtain the most realistic understanding of pollution health effects and their implications, it is necessary to:

“Measure where the people are”

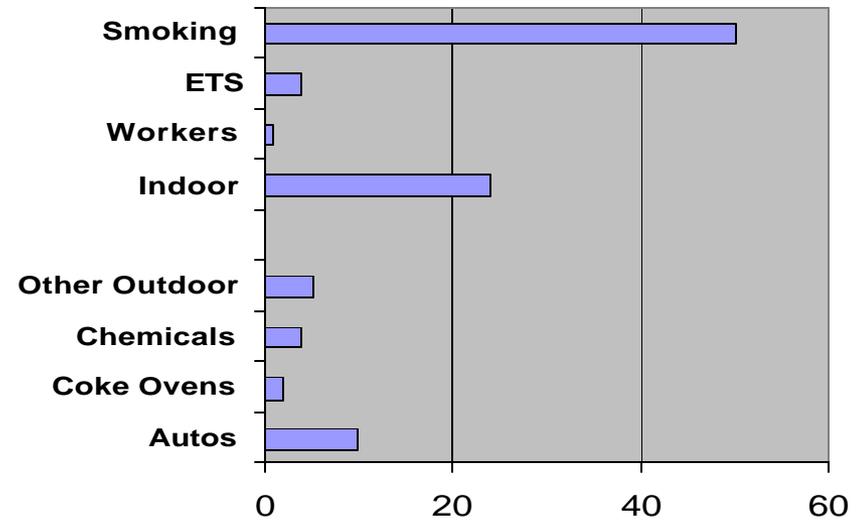
Lance Wallace, USEPA

# Benzene Pollution in the USA ~1990

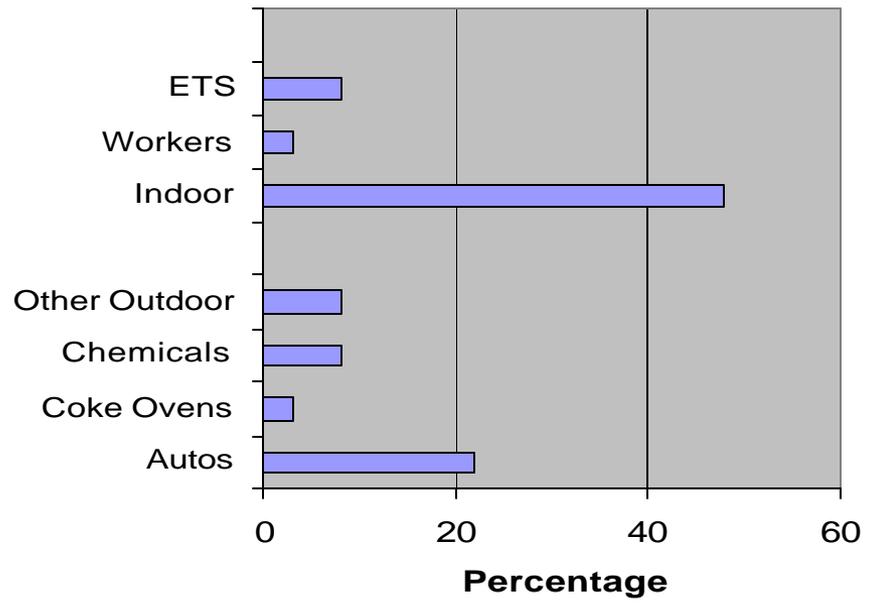
### National Emissions



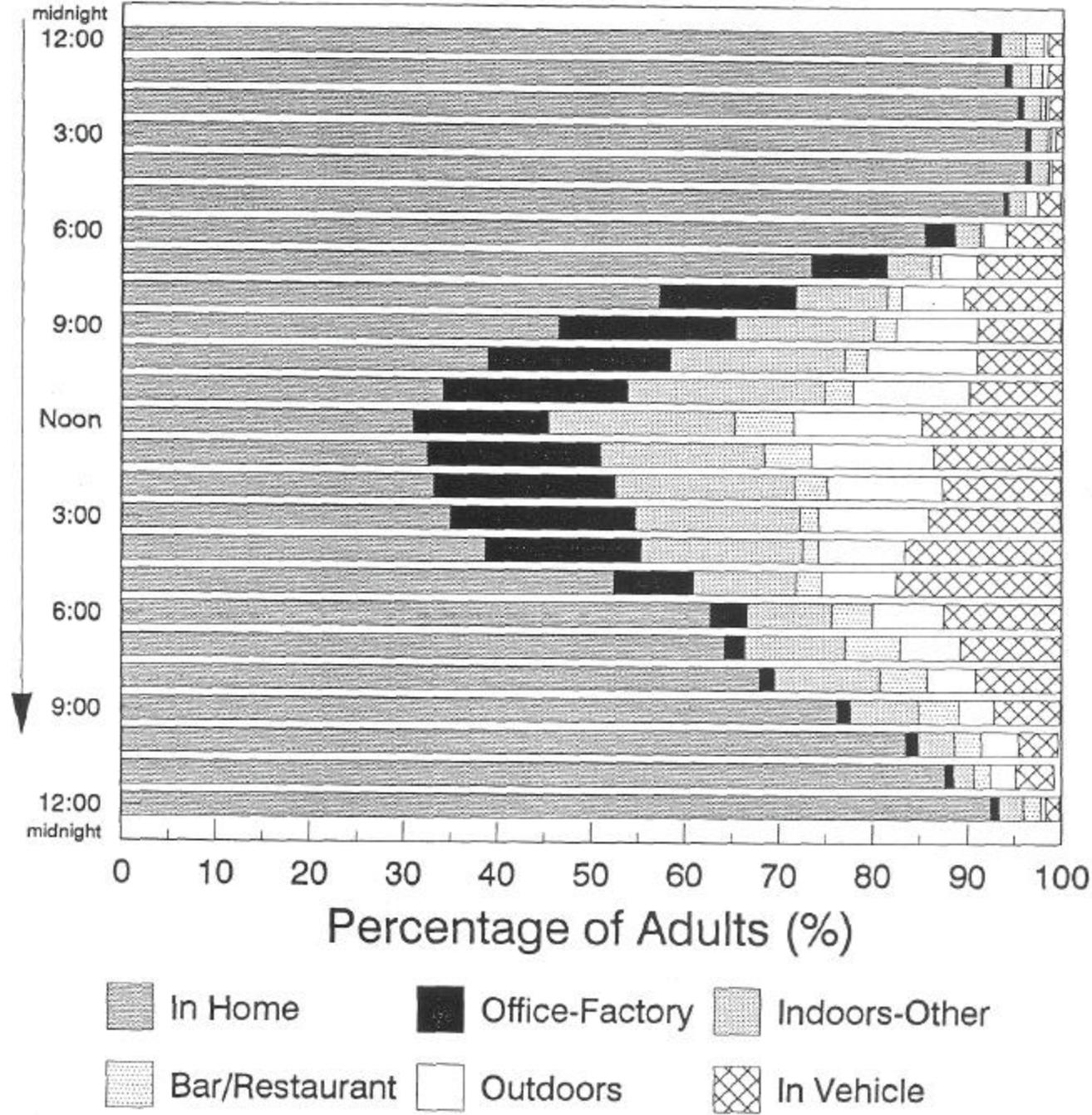
### National Exposures



### Involuntary Exposures

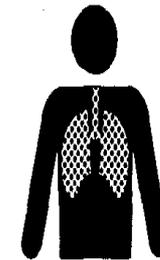
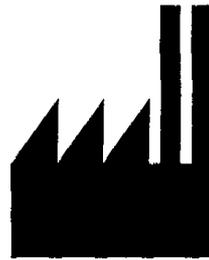


# Location of California Adults by Time of Day



# Exposure considers where the people are

SOURCE → EMISSIONS → CONCENTRATION → EXPOSURE → DOSE → HEALTH EFFECTS



**Where are the people?**

- How many, where, when, and for how long?
- Which kind of people (age, sex, health status) doing what (resting, working)

# Indoor Air Pollution

- People spend an average of 90 percent of their time indoors while some at-risk subgroups such as the elderly, very young, and chronically ill may spend nearly all their time indoors.

# Sources of Indoor Air Pollution

- Fuel burning: wood, coal, kerosene, oil, gas
- Burning of tobacco, incense, mosquito coils
- Cleaning products
- Furnishings, carpets
- Paints
- Radon from the ground
- Moisture, molds, mildew, etc.

# Major Sources of Emissions and Exposures in the USA

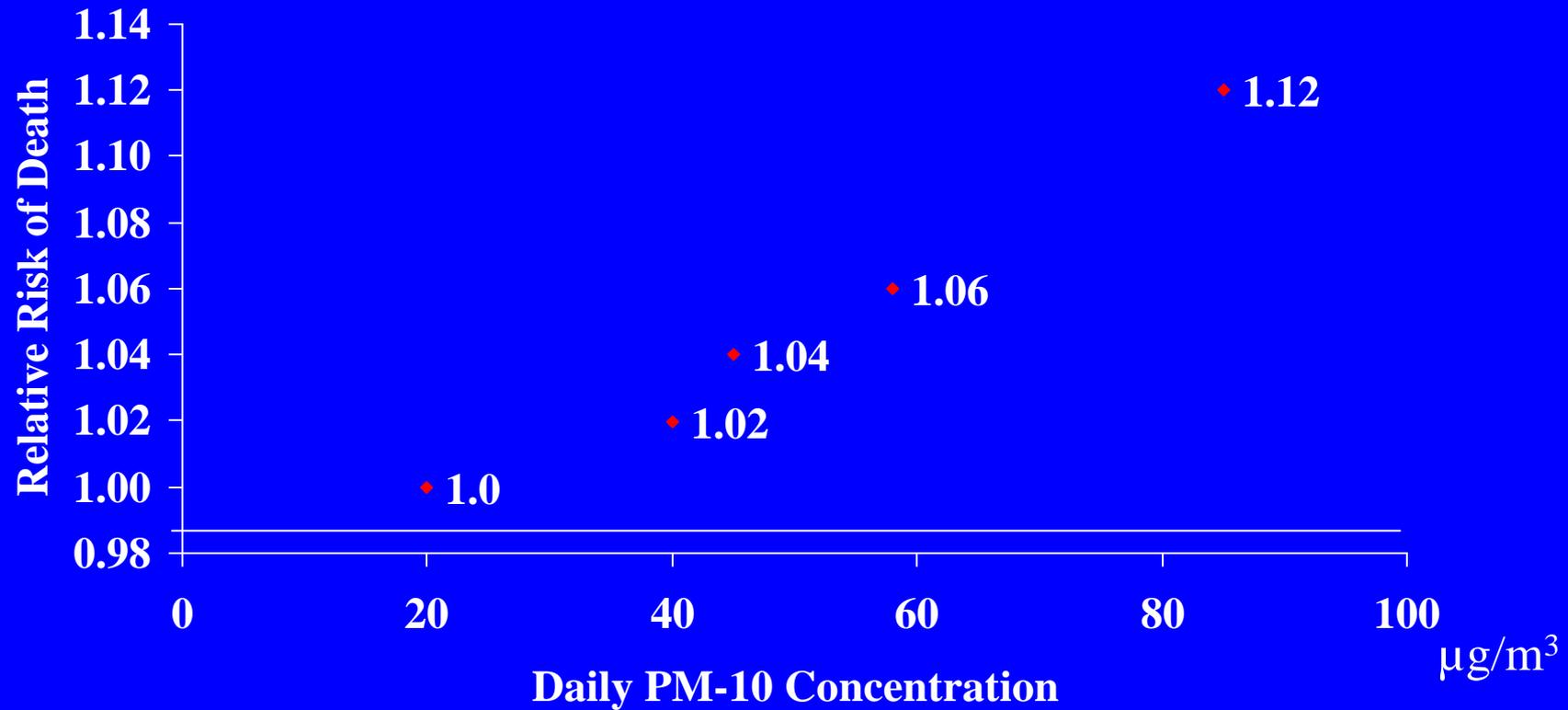
<b>Pollutant</b>	<b>Effect</b>	<b>Emissions</b>	<b>Exposures</b>
<b>Particles</b>	Resp Disease	Autos, industry	ETS
<b>Benzene</b>	Leukemia	Autos, industry	ETS, household products
<b>Tetrachloro-ethylene</b>	Cancer	Dry-cleaning	Dry-cleaned clothes
<b>Chloroform</b>	Cancer	Sewage plants	Chlorinated water in showers
<b>Nitrogen Dioxide</b>	Resp. Disease	Autos, industry	Gas Stoves
<b>Carbon Monoxide</b>	Heart Disease	Autos	Driving, gas stoves

# Why does outdoor pollution link so well with health effects if indoor air pollution is important?

- If, personal exposures are what cause health effects, and
- Personal exposures are affected by both outdoor and indoor pollution, and
- Indoor pollution exposure is often as important or more so than outdoor pollution; then
- Why does it work so well to determine health effects by examining only outdoor pollution and ignoring indoor?

# Sample Exposure-Response Relationship

## Airborne Particle Risks: Utah Valley Study

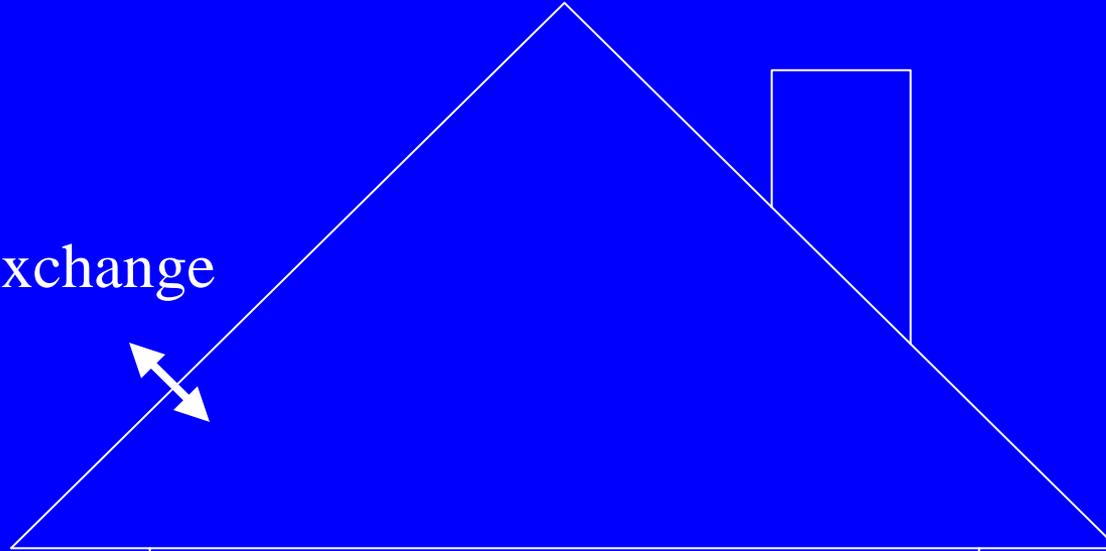


**Outdoor Only!**

# Indoor and outdoor pollution

Outdoor  
Pollution

Air Exchange  
Rate



Exposures  
are due both  
to indoor  
sources and  
outdoor pollution  
penetrating  
indoors

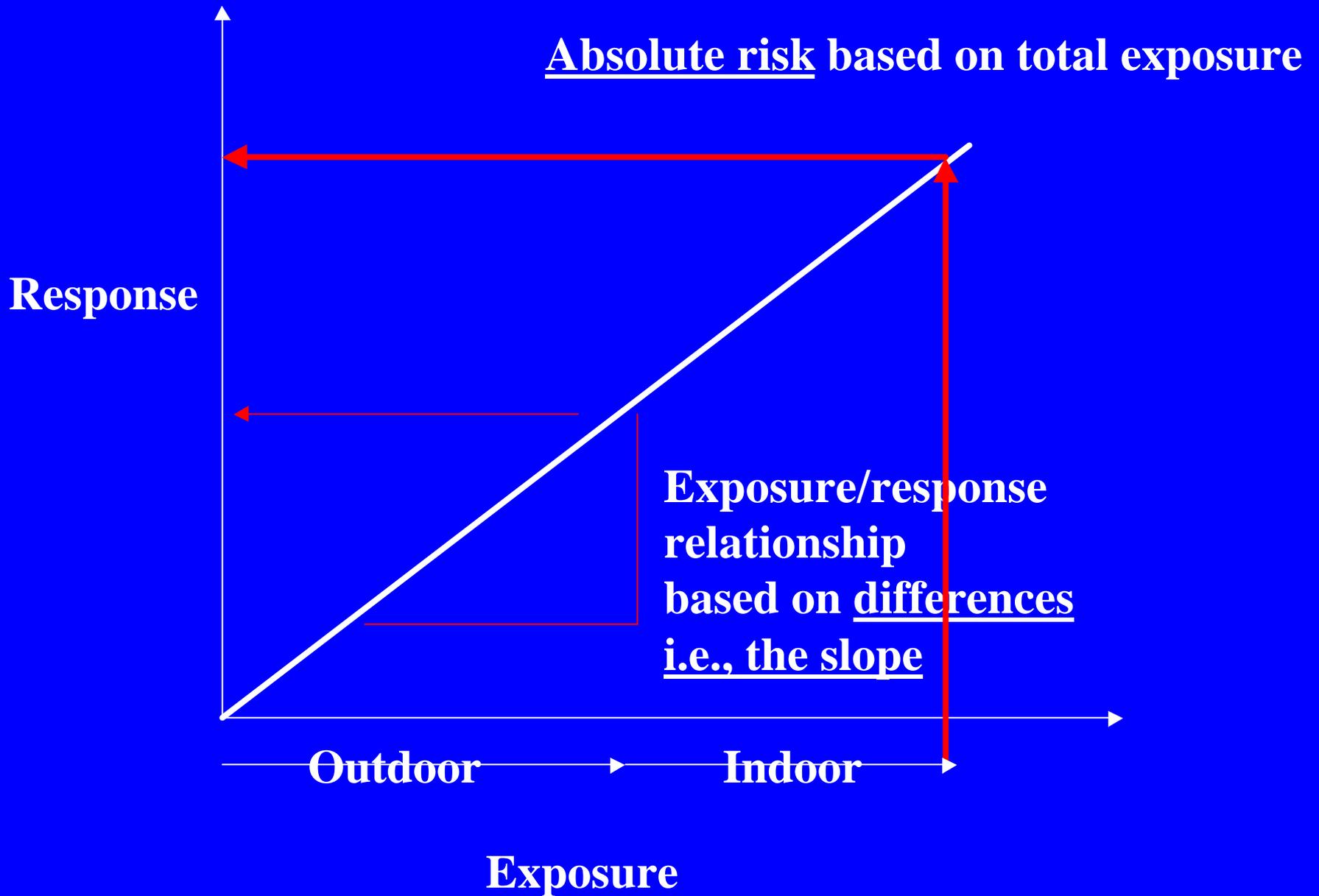


Indoor  
concentrations

Indoor pollution  
source

# Outdoor air pollution epidemiology

- Changes in outdoor pollution are compared to changes in health effects
  - Time-series study: outdoor air pollution goes up, health effects go up next day
  - Cohort studies: outdoor pollution is higher in one city over a year than in another as are health effects
- Indoor sources, however, do not vary in the same way as outdoor pollution.
  - They may go up/down on a daily or weekly schedule, but not in the same way as outdoor pollution
  - Except for such important factors as smoking, which are accounted for in the studies, they do not vary annually according to city.



# How would exposure be used instead of ambient concentrations in policy?

- Measure personal exposure?
  - Expensive, intrusive, difficult
  - Not practical for routine application
- Categorize and rank emission sources by their exposure implications?

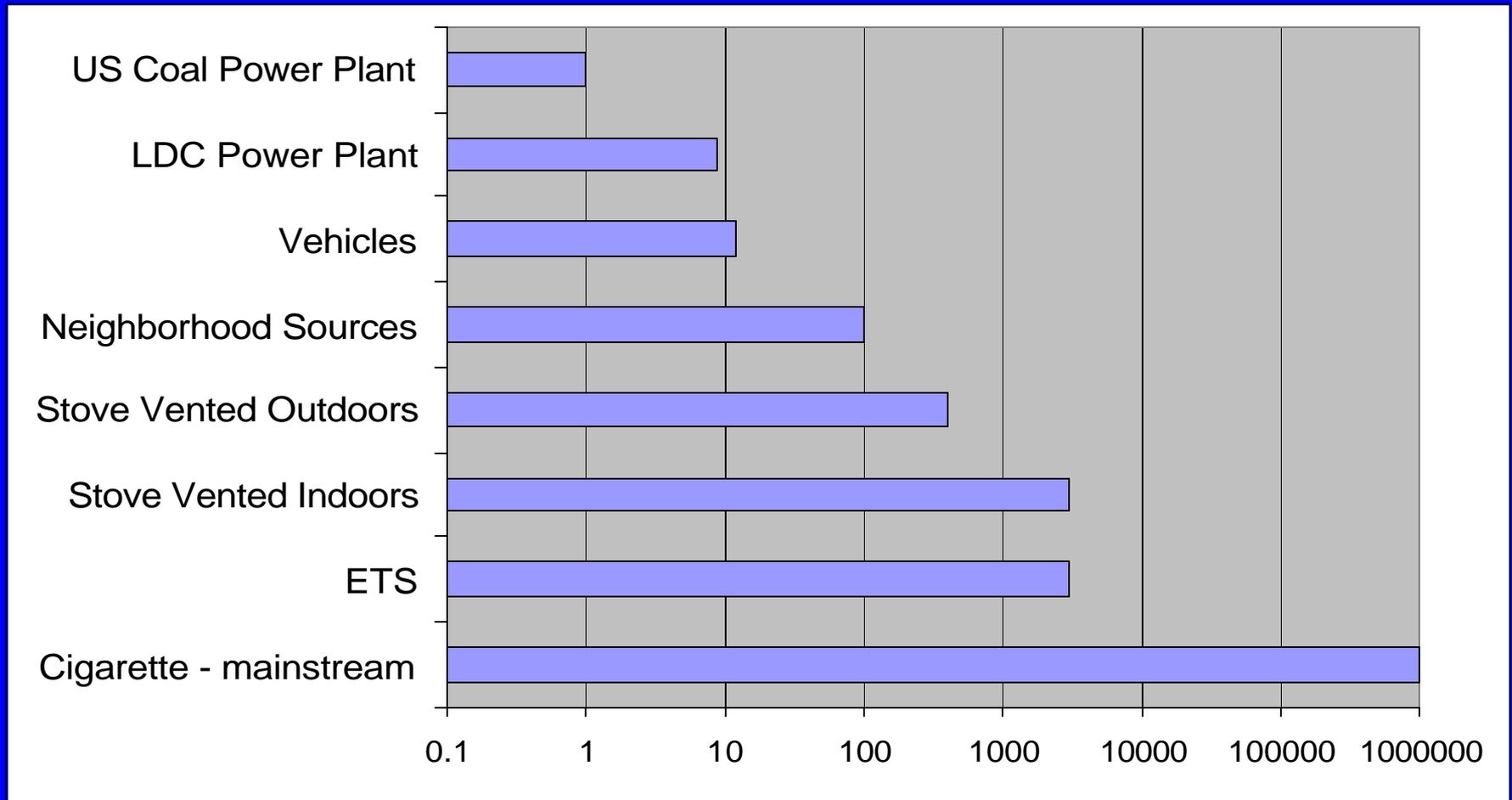
## This Can be Done Though the Concept of *Intake Fraction (IF)*

- *IF* is the fraction of material emitted that crosses some person's physiological barriers (skin, GI tract, Resp. tract, etc.)
- For air pollution, *IF* is the fraction breathed in by the exposed population.



IF = 1.0

# Intake Fractions : these are rough calculations for typical examples of sources in each class



Smith, 1993

Grams Inhaled per Ton Emitted

# Exposure effectiveness or intake fraction

- Where a pollutant is released is as important as what is released
- “Rule of One Thousand” = Pollutants released indoors are about 1000 times more likely to reach someone’s lungs than if released outdoors.
- This has significant effects on the relative importance of different pollution sources.
- For example, even though there is more than 40 times more particle pollution released from US coal power plants than from cigarettes, a 3% reduction in passive smoking would be equivalent to eliminating all the power plants in the country in terms of particle exposure to people.

# Comparisons of Annual Population Intakes in California Based on IF Calculations

- Vehicles
  - 140 t CO
  - 12-40 kg benzene
  - 400 kg PM
- ETS
  - 8 t CO
  - 35 kg benzene
  - 1300 kg PM

**Nazaroff & Lai,  
2000**

# Environmental Tobacco Smoke

## Strong Evidence (dozens of studies)

- Acute Lower Respiratory Infections in children under 5 *OR= 1.4-1.7*
- Otitis Media in children under 5: *OR= 1.1-2.0*
- Asthma attacks in children under 15: *OR= 1.2-1.6*
- Lung cancer in adults: *OR= 1.1-1.4*

# Growing Evidence of other ETS Health Impacts

- Heart disease
- Stroke
- Low birth weight, stillbirth, and other adverse pregnancy outcomes
- Sudden infant death syndrome

Intake fraction varies because emissions are a function of where and when the people spend time



What is the relation of the source to exposure? (intake fraction)

Where are the people?

- How many, where, when, and for how long?
- Which kind of people (age, sex, health status) doing what (resting, working)

# **Instead of *Emissions Regulation*, could there be *Exposure Regulation*?\***

## **How would it be done?**

- **Establish IFs for all major source categories**
- **Weight emissions by IFs to determine nominal intakes**
- **Regulate by nominal intake quantities, not emissions.**

## **Problems**

- **Could acceptable and repeatable methods to determine IFs be established?**
- **Would the (sometimes substantial) difference in control priorities be politically acceptable?**

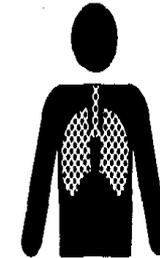
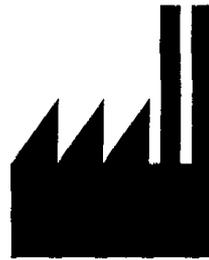
**\* Or Trading**

# What regulatory levers are available?

- Appliance standards
- Fuel standards
- Building codes
- Consumer product regulations
- Rules for operation of hospitals, schools, nursing homes, and other places with vulnerable groups
- Public information and education
- Medical interventions, for example, prescribing air cleaners
- More.....

# Environmental Pathway

SOURCE → EMISSIONS → CONCENTRATION → EXPOSURE → DOSE → HEALTH EFFECTS



Best Controls

Best Measurements

Most Concern

# Bottom lines

1. For health, it is not only how much is emitted and how toxic it is, but how much of it actually reaches people
2. Pollution released indoors is much more likely to reach people
3. There are ways to regulate indoor air pollution without draconian or even new methods.

“We feel it should be built away from population centres.”

And certainly not indoors, if we can avoid it!

