

# *Particulate Matter (PM): Adverse Health Effects*

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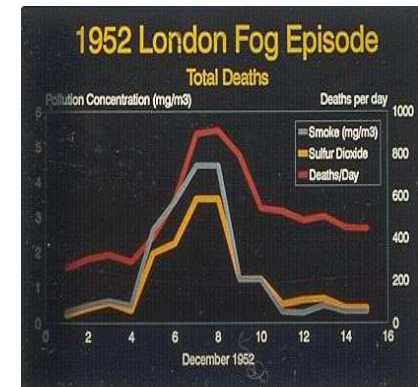
**California Air Resources Board**

**Thursday, November 19, 2009**

L'opera nella sala  
 è in bronzo, alta 100 cm.  
 Ediz. numerata di 40.  
 Ediz. 1993 del 100%.

È la scultrice la protagonista di questo  
 volume che, grazie a un'ampia e preziosa  
 ricerca, ci rivela un'artista di grande  
 valore, la cui opera è stata  
 finora poco conosciuta.

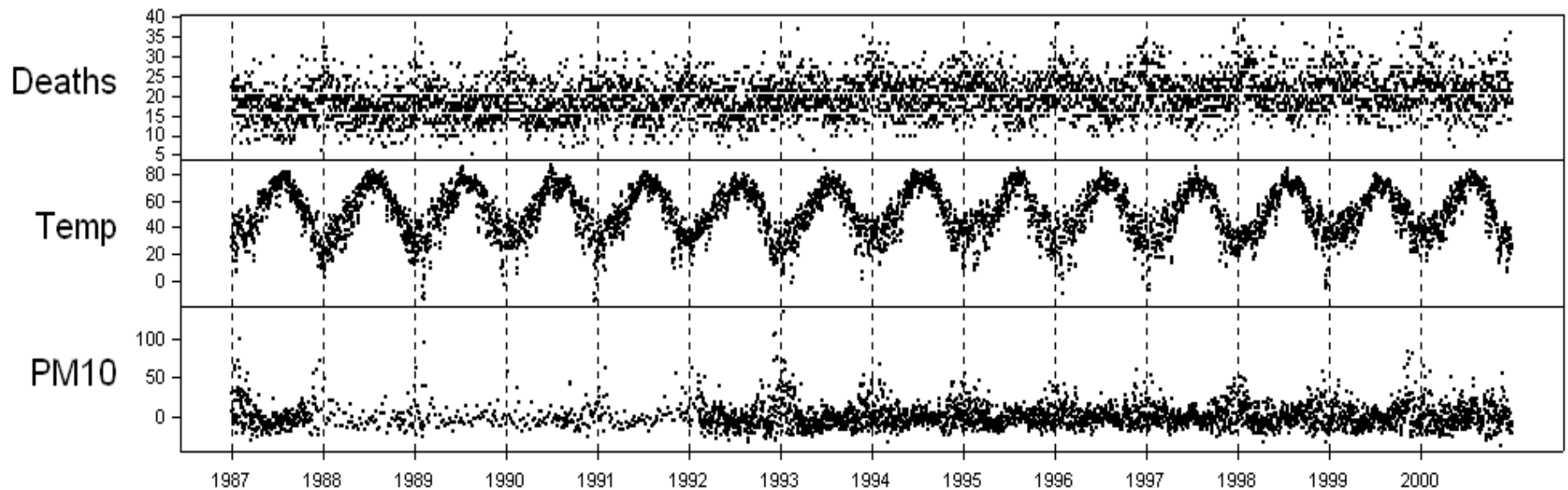
Una scoperta che ha  
 permesso di conoscere  
 un'artista di grande  
 valore.

1953  
week

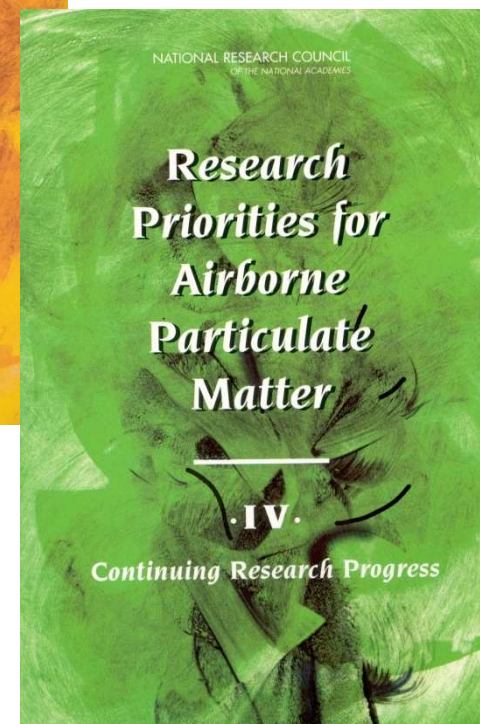
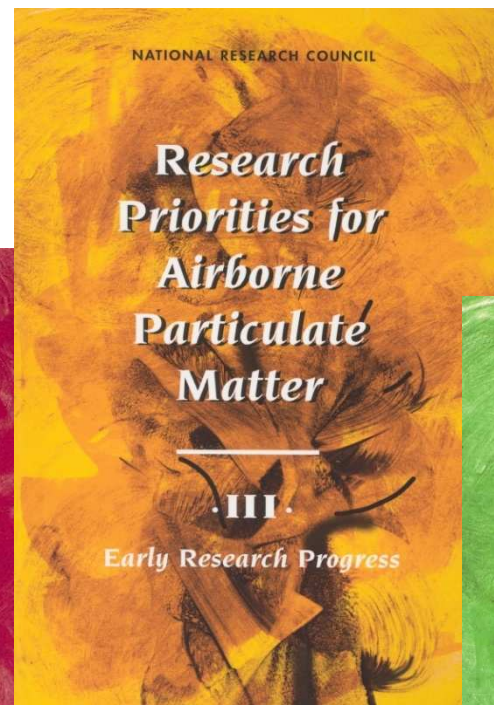
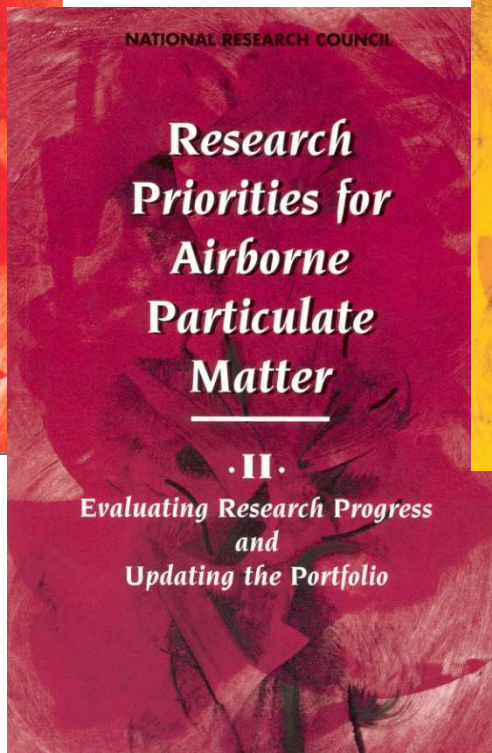
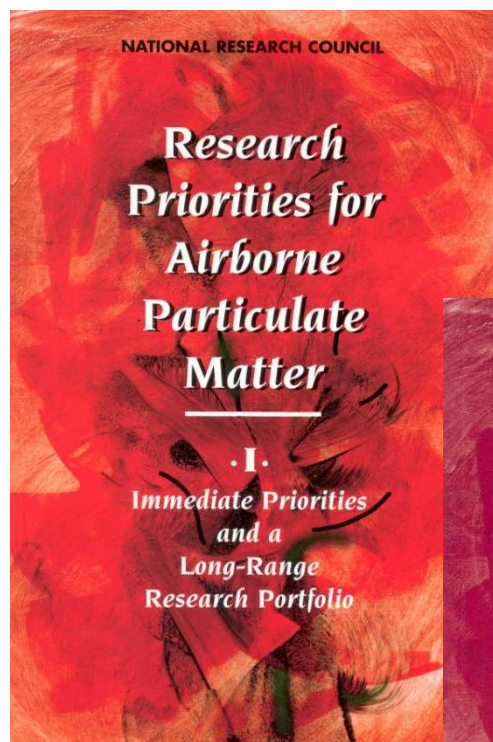
Beginning on October 26, 1948, sparse air movement contributed to a temperature inversion in the atmosphere over western Pennsylvania, Ohio, and areas of neighboring states. A fog laden with particulates and other industrial contaminants saturated the air of Donora, a small industrial town on the banks of the Monongahela River, some 30 miles south of Pittsburgh. Visibility was so poor that even locals lost their sense of direction. An estimated 5000 to 7000 persons in a town of 14000 residents became ill, some 400 required hospitalization, and 20 died before rain dispersed the killing smog on October 30 and 31, 1948. *Helfand et al.*



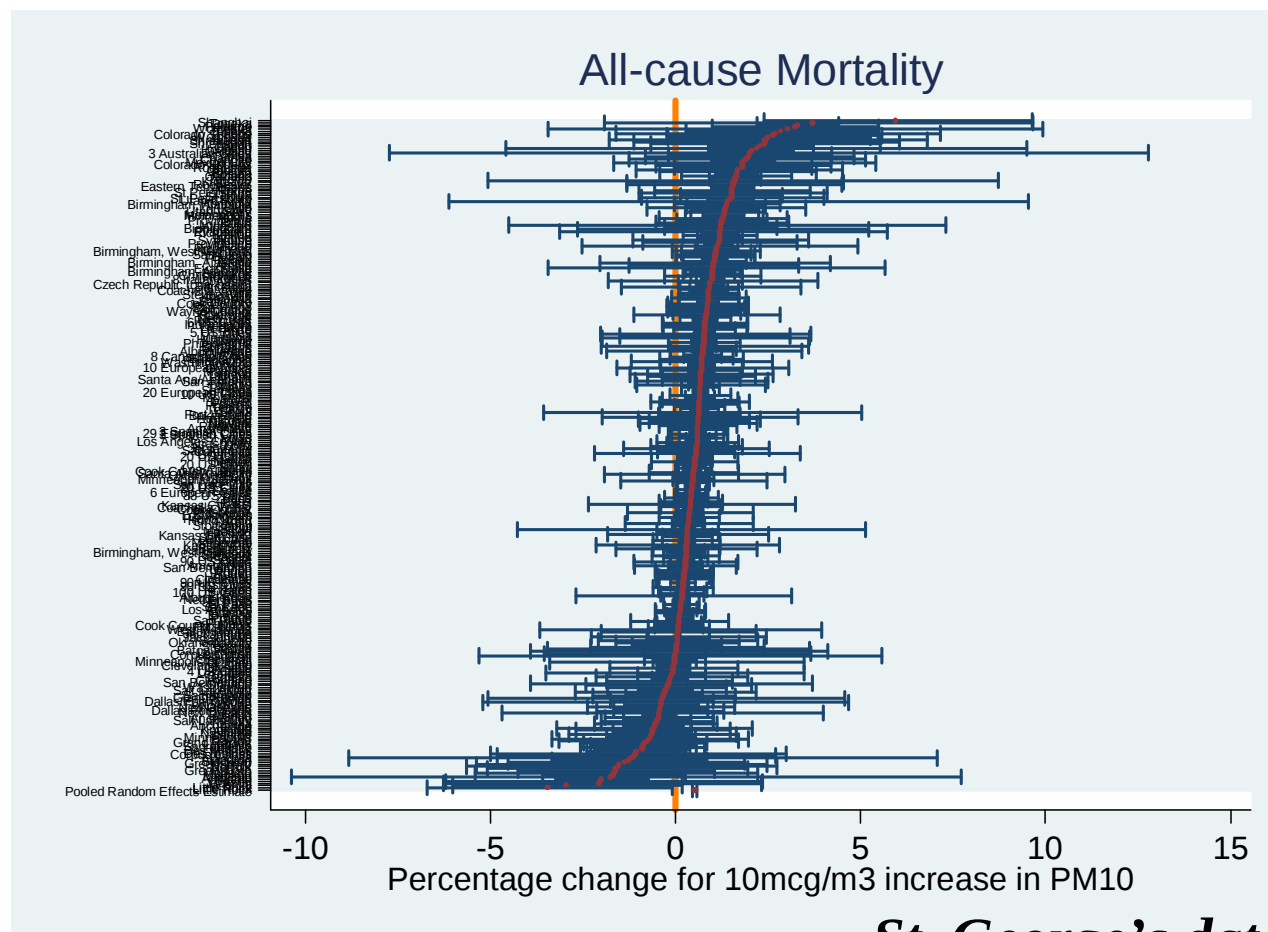
# National Morbidity Mortality Air Pollution Study



# National Research Council's PM Committee



# Time-series estimates to 2006: Daily all-cause mortality and $PM_{10}$ (n=314)



# **Integrated Science Assessment for Particulate Matter**

## **Second External Review Draft**

ISA: EPA/600/R-08/139B  
ANNEXES: EPA/600/R-08/139BA

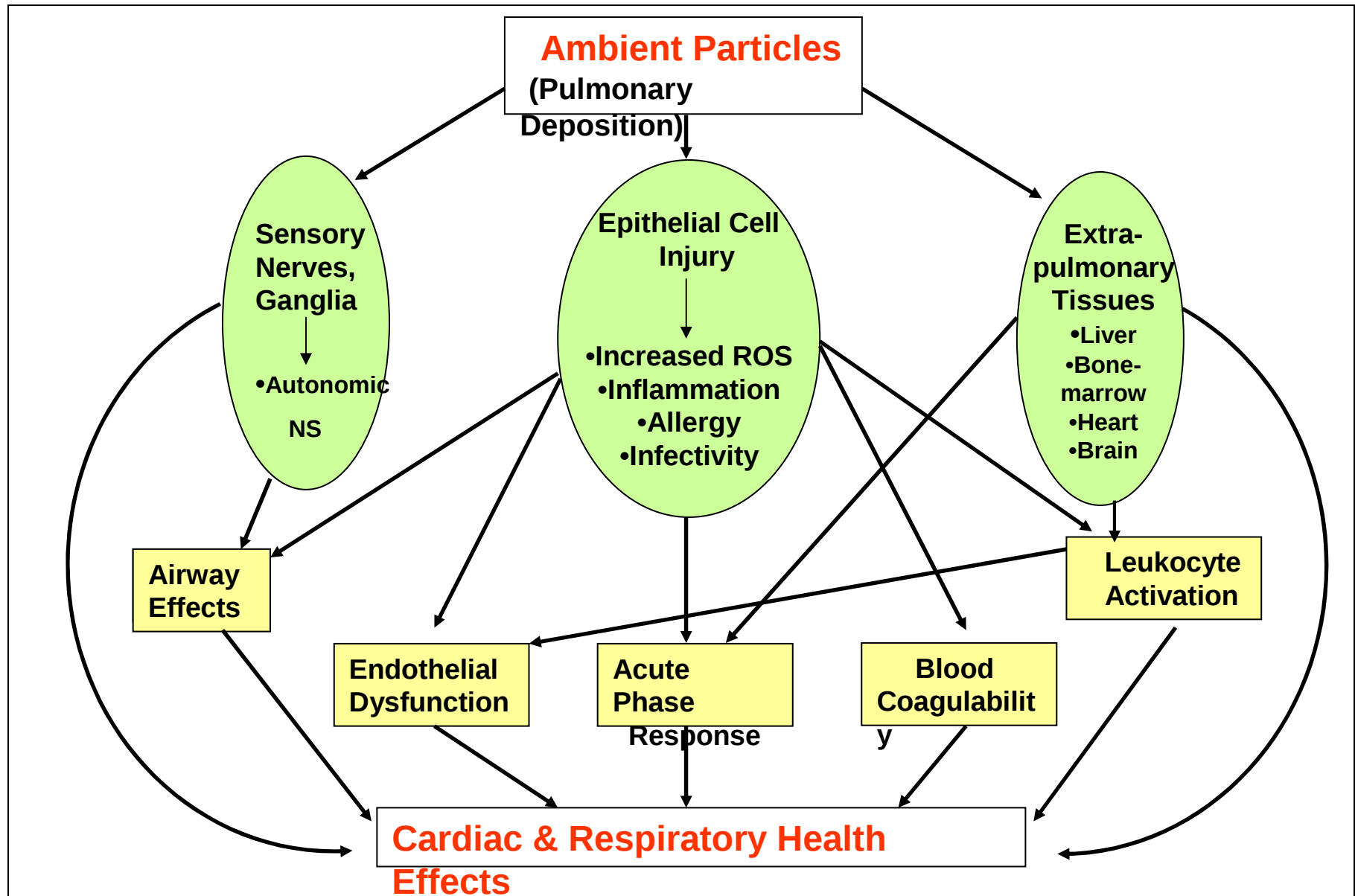
National Center for Environmental Assessment-RTP Division  
Office of Research and Development  
U.S. Environmental Protection Agency  
Research Triangle Park, NC

# EPA's Evidence Classification

**Table 1-3. Weight of evidence for causal determination.**

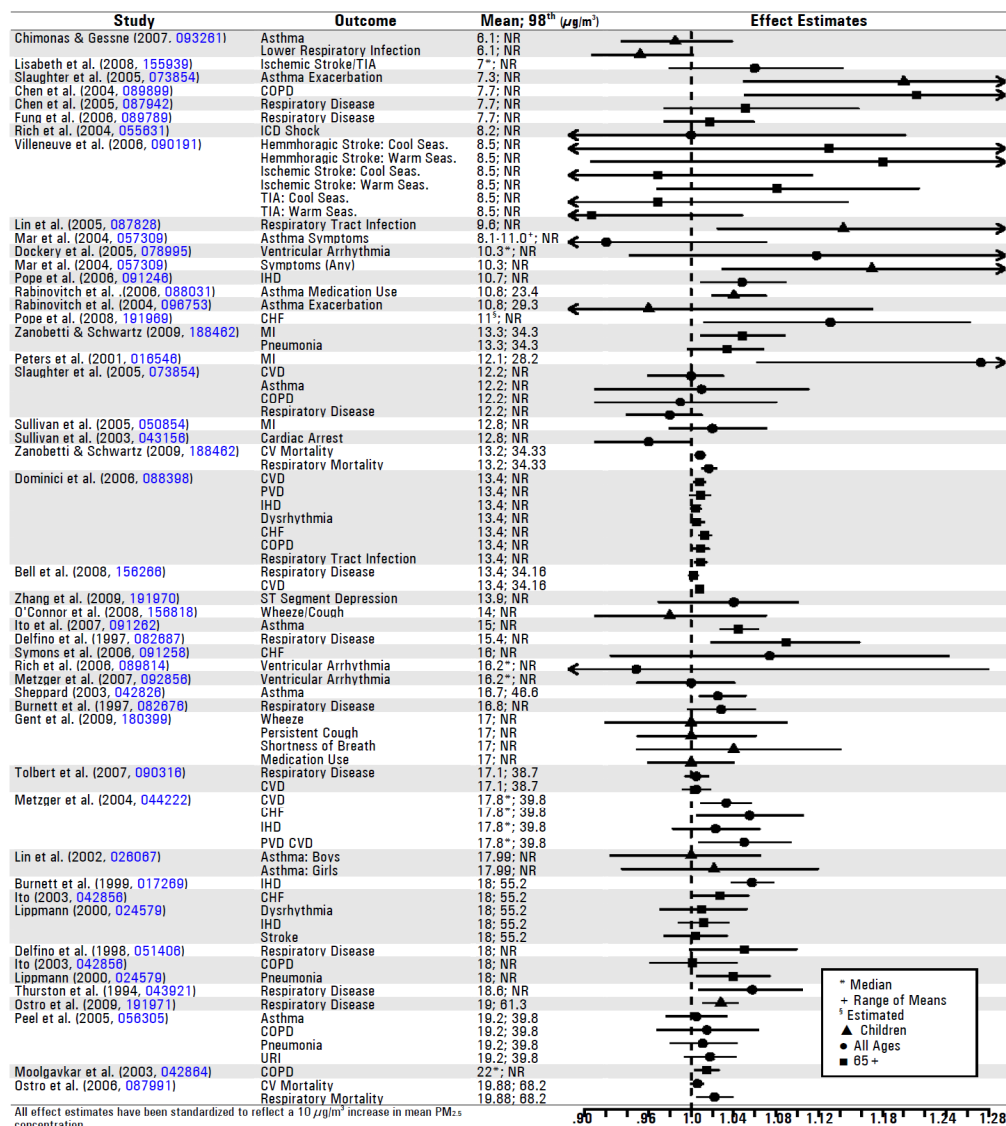
| Determination                                    | Health Effects                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Ecological and Welfare Effects                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Causal relationship</b>                       | Evidence is sufficient to conclude that there is a causal relationship with relevant pollutant exposures. That is, the pollutant has been shown to result in health effects in studies in which chance, bias, and confounding could be ruled out with reasonable confidence. For example: a) controlled human exposure studies that demonstrate consistent effects; or b) observational studies that cannot be explained by plausible alternatives or are supported by other lines of evidence (e.g., animal studies or mode of action information). Evidence includes replicated and consistent high-quality studies by multiple investigators.                                                                                                                                                                                           | Evidence is sufficient to conclude that there is a causal relationship with relevant pollutant exposures. That is, the pollutant has been shown to result in effects in studies in which chance, bias, and confounding could be ruled out with reasonable confidence. Controlled exposure studies (laboratory or small- to medium-scale field studies) provide the strongest evidence for causality, but the scope of inference may be limited. Generally, determination is based on multiple studies conducted by multiple research groups, and evidence that is considered sufficient to infer a causal relationship is usually obtained from the joint consideration of many lines of evidence that reinforce each other. |
| <b>Likely to be a causal relationship</b>        | Evidence is sufficient to conclude that a causal relationship is likely to exist with relevant pollutant exposures, but important uncertainties remain. That is, the pollutant has been shown to result in health effects in studies in which chance and bias can be ruled out with reasonable confidence but potential issues remain. For example: a) observational studies show an association, but copollutant exposures are difficult to address and/or other lines of evidence (controlled human exposure, animal, or mode of action information) are limited or inconsistent; or b) animal toxicological evidence from multiple studies from different laboratories that demonstrate effects, but limited or no human data are available. Evidence generally includes replicated and high-quality studies by multiple investigators. | Evidence is sufficient to conclude that there is a likely causal association with relevant pollutant exposures. That is, an association has been observed between the pollutant and the outcome in studies in which chance, bias and confounding are minimized, but uncertainties remain. For example, field studies show a relationship, but suspected interacting factors cannot be controlled, and other lines of evidence are limited or inconsistent. Generally, determination is based on multiple studies in multiple research groups.                                                                                                                                                                                |
| <b>Suggestive of a causal relationship</b>       | Evidence is suggestive of a causal relationship with relevant pollutant exposures, but is limited because chance, bias and confounding cannot be ruled out. For example, at least one high-quality epidemiologic study shows an association with a given health outcome but the results of other studies are inconsistent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Evidence is suggestive of a causal relationship with relevant pollutant exposures, but chance, bias and confounding cannot be ruled out. For example, at least one high-quality study shows an effect, but the results of other studies are inconsistent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Inadequate to infer a causal relationship</b> | Evidence is inadequate to determine that a causal relationship exists with relevant pollutant exposures. The available studies are of insufficient quantity, quality, consistency or statistical power to permit a conclusion regarding the presence or absence of an effect.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of an effect.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Not likely to be a causal relationship</b>    | Evidence is suggestive of no causal relationship with relevant pollutant exposures. Several adequate studies, covering the full range of levels of exposure that human beings are known to encounter and considering susceptible or vulnerable subpopulations, are mutually consistent in not showing an effect at any level of exposure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Several adequate studies, examining relationships with relevant exposures, are consistent in failing to show an effect at any level of exposure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

# Biological Mechanisms of PM: Exposure to Effects



Source: Utell, Univ. Rochester, 2003

# Short-term Exposure to PM<sub>2.5</sub> and Mortality



**Figure 2-1.** Excess risk estimates from epidemiologic studies of PM<sub>2.5</sub> ordered by mean 24-h avg concentration as reported by the investigator.

**Table 2-1** Summary of causal determinations for short-term exposure to PM<sub>2.5</sub>.

| Size Fraction     | Outcome                | Causality Determination |
|-------------------|------------------------|-------------------------|
| PM <sub>2.5</sub> | Cardiovascular Effects | Causal                  |
|                   | Respiratory Effects    | Likely to be causal     |
|                   | Mortality              | Likely to be causal     |

# Long-term Exposure to PM<sub>2.5</sub> and Mortality

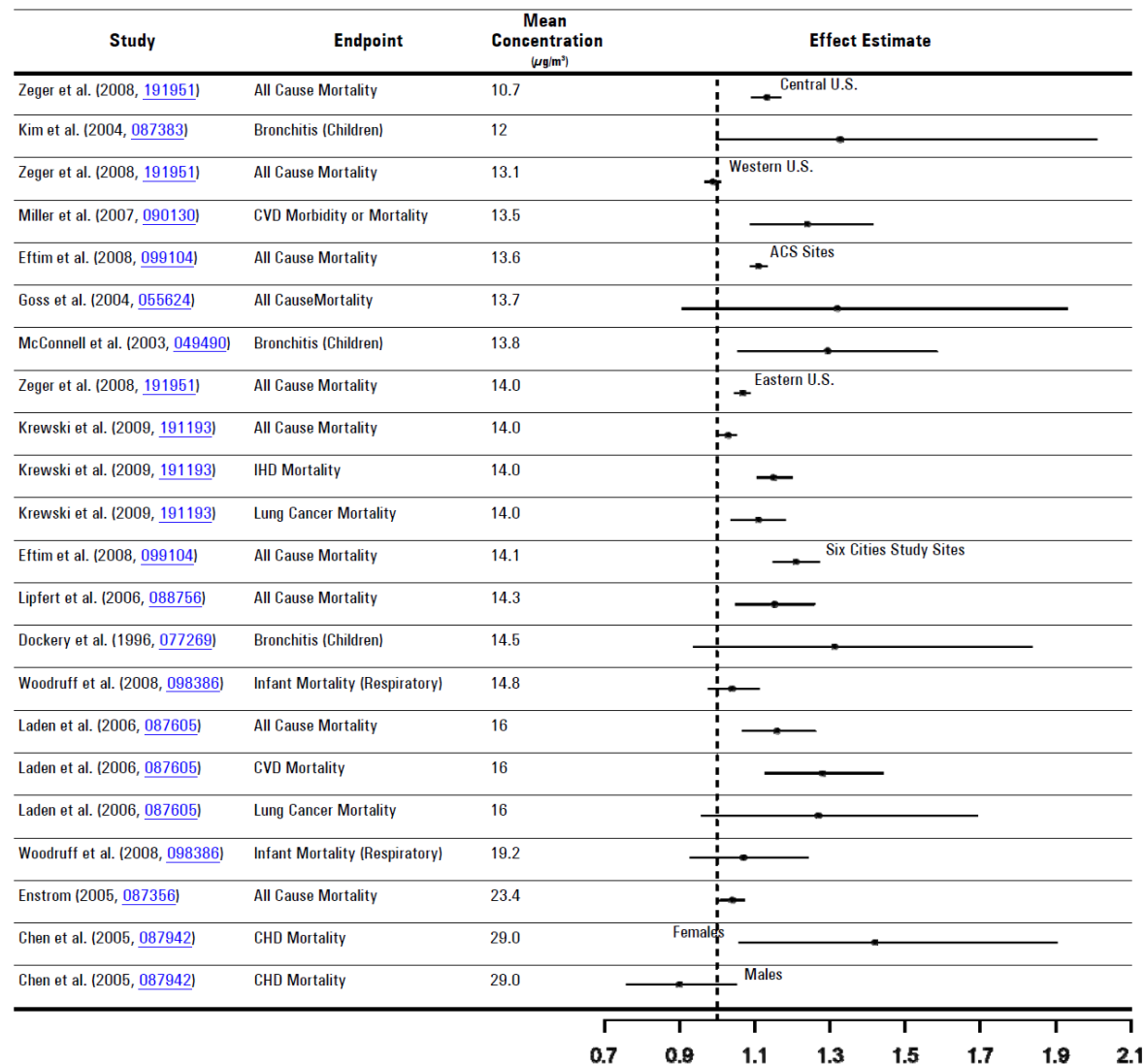


Figure 2-2.

Summary of U.S. studies examining the association between long-term exposure to PM<sub>2.5</sub> and CVD morbidity/mortality, respiratory morbidity/mortality, and all-cause mortality conducted in locations where the mean annual PM<sub>2.5</sub> concentration ranged from 10.7-29  $\mu\text{g}/\text{m}^3$ . All effect estimates have been standardized to reflect a 10  $\mu\text{g}/\text{m}^3$  increase in mean annual PM<sub>2.5</sub> concentration.

**Table 2-2. Summary of causal determinations for long-term exposure to PM<sub>2.5</sub>.**

| Size Fraction     | Outcome                                | Causality Determination |
|-------------------|----------------------------------------|-------------------------|
| PM <sub>2.5</sub> | Cardiovascular Effects                 | Causal                  |
|                   | Respiratory Effects                    | Likely to be causal     |
|                   | Mortality                              | Likely to be causal     |
|                   | Reproductive and Developmental         | Suggestive              |
|                   | Cancer, Mutagenicity, and Genotoxicity | Suggestive              |

**Table 2-3. Summary of causal determinations for short-term exposure to PM<sub>10-2.5</sub>.**

| Size Fraction        | Outcome                | Causality Determination |
|----------------------|------------------------|-------------------------|
| PM <sub>10-2.5</sub> | Cardiovascular Effects | Suggestive              |
|                      | Respiratory Effects    | Suggestive              |
|                      | Mortality              | Suggestive              |

**Table 2-4. Summary of causal determinations for short-term exposure to UFPs.**

| Size Fraction       | Outcome                | Causality Determination |
|---------------------|------------------------|-------------------------|
| Ultrafine Particles | Cardiovascular Effects | Suggestive              |
|                     | Respiratory Effects    | Suggestive              |

