Rethinking Meta-analysis: Applications for Air Pollution Data and Beyond

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Methods for Research Synthesis: A Cross-Disciplinary Approach,
Cambridge, Massachusetts
October 3, 2013

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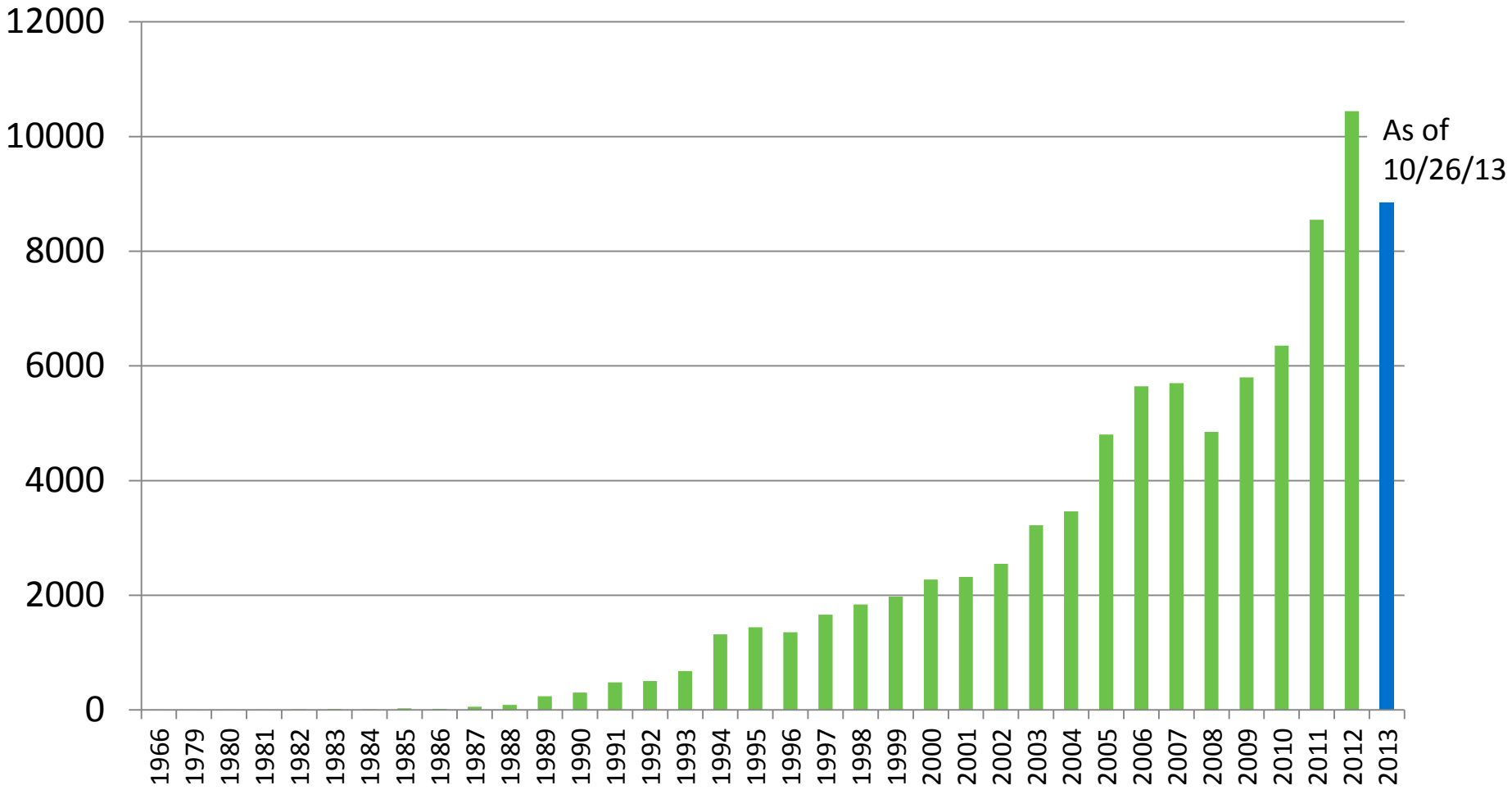
Number of Publications in Scopus with Meta-Analysis in Title, Abstract, and/or Keywords



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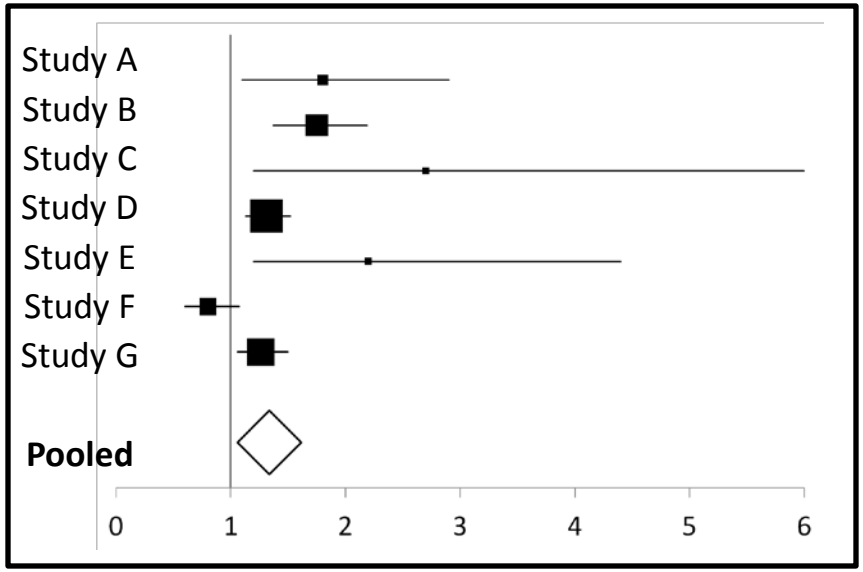
Meta-Analysis

- Systematic review of data from comparable studies leading to a quantitative summary of results
- Data types
  - *e.g.*, binary, ordinal, categorical, continuous, counts, percentages
- Any discipline
- Studies must address the same question
- Policy applications



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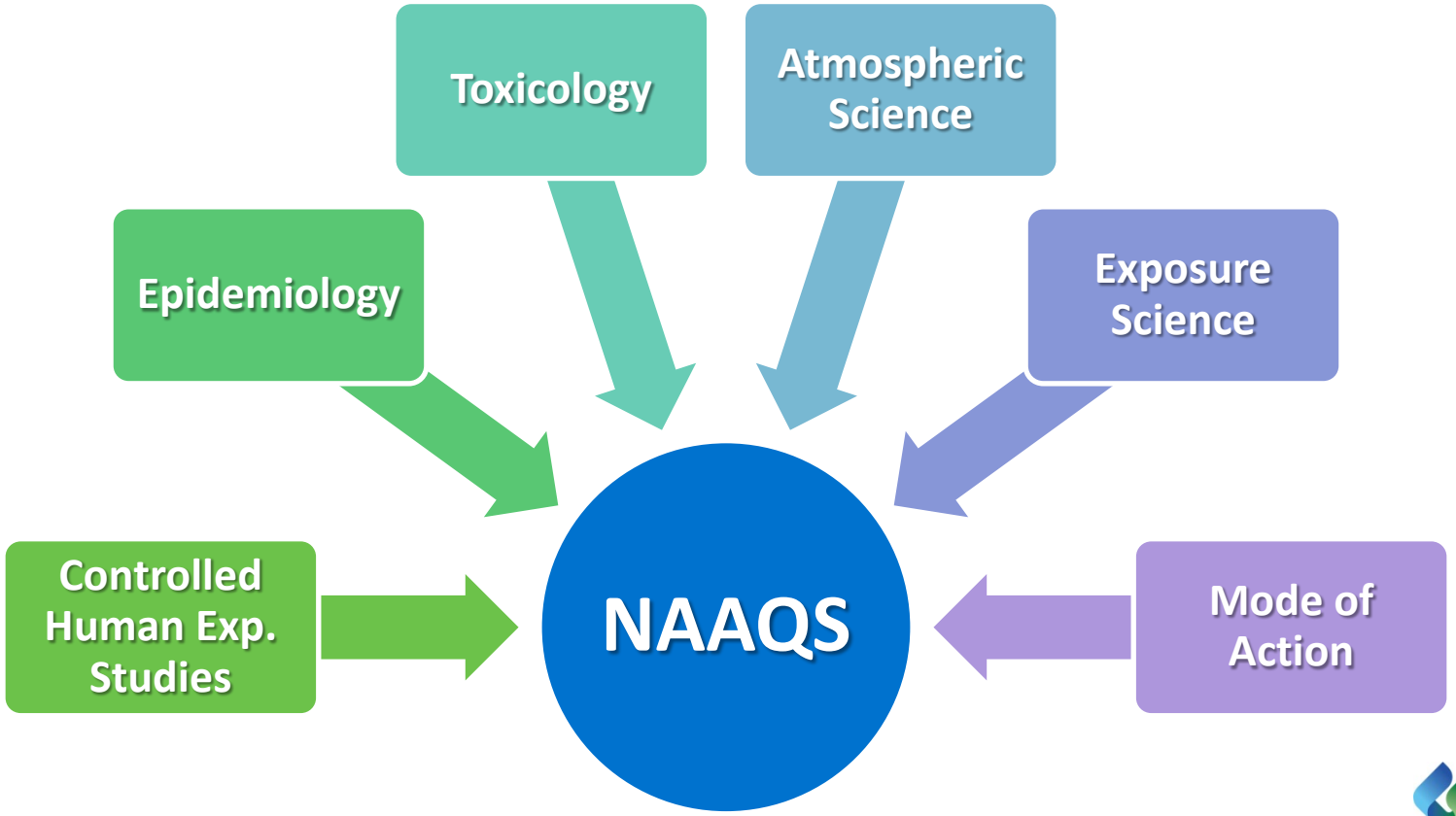
National Ambient Air Quality Standards (NAAQS)

- Developed by US EPA for PM, SO_x, NO_x, CO, O_3, Pb
- Protect public health, public welfare, and environment
- Based on a weight-of-evidence evaluation of data from a variety of disciplines



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Using Meta-analysis for Different Types of Air Pollution Data

Data Category	Controlled Exposure Studies	Epidemiology Studies	Toxicity Studies	Mechanistic/ Mode-of-Action Studies
Potential Sample Size	↓	↑	↓	↓
Controlled Exposure/Outcome	↑	↓	↑	↑
Potential for standardized design	↑	↑↓	↑	↑
Data complexity	↓	↑	↓	↑↓
Potential for bias	↓	↑	↓	↓
Potential for heterogeneity	↓	↑	↑↓	↑↓
Published meta-analyses	↑	↑	↓	↓

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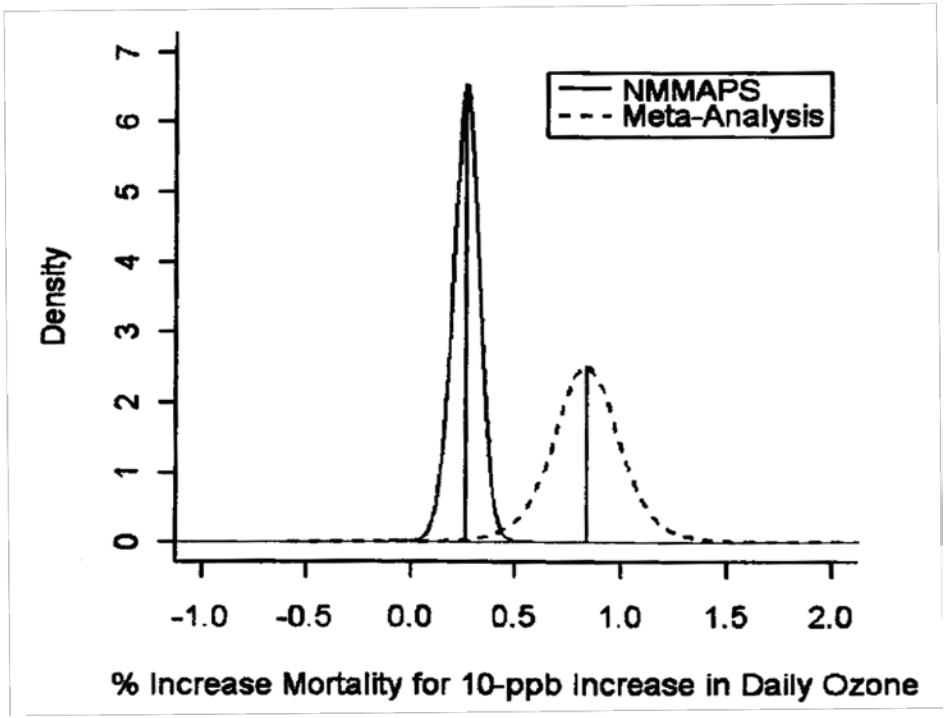
Meta-analysis Limitations

- Limited to homogeneous studies
- Cannot mitigate limitations in underlying data
  - Incomplete reporting or analysis
  - Bias (*e.g.*, selection, reporting, publication)
- Can get different results depending on question asked
- Can't address adversity



Bell *et al*. (2005)

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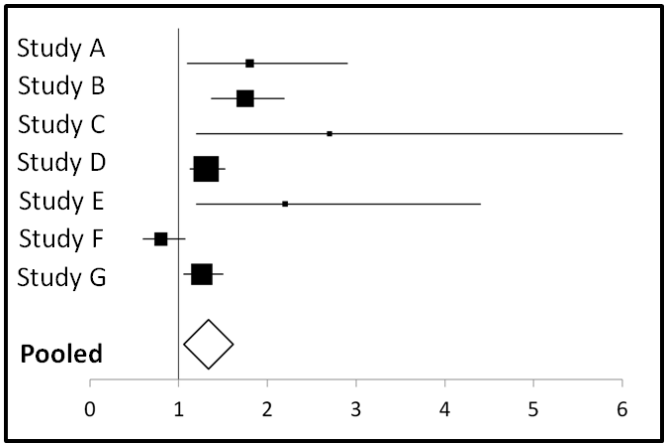
Meta-analysis Benefits



- Provide a standardized, transparent approach
- Enhance statistical power to detect an effect
- Evaluate sources/influences of heterogeneity and bias
- Can use different and novel statistical methods
  - Calculate magnitude of outcome
  - Evaluate correlation (*e.g.*, dose-response)
  - Conduct sensitivity analyses
- Identify data gaps
- Identify research strategies for future study design/data analysis/reporting

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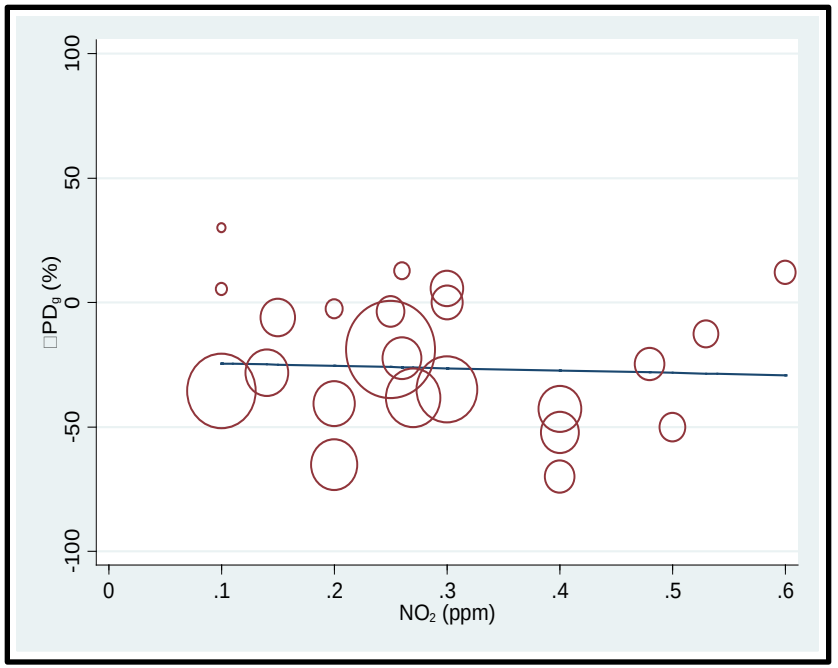
Research Frontiers

- Enhanced applications of existing approaches (*e.g.*, dose-response)
- New applications in evolving research areas/study types (*e.g.*, gene expression)
- New statistical approaches (*e.g.*, address big data, study limitations, confounders, heterogeneity)
- Improved, informed consistency of original research
- Guideline development



Goodman *et al.* (2009)

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Policy Applications

- Systematically review studies that bear on policy
- Apply to studies in different disciplines
- Identify data gaps and new studies to conduct
- Base regulations on weight of evidence, not one study

Nickel Unit Risk Factor Derivation Based on Two Studies

Study	Unit Risk Factor (per ug/m^3)	Weight
Grimsrud et al. (2003)	2.59×10^{-4}	59%
Enterline and Marsh (1982)	4.34×10^{-5}	41%
Final URF	**1.7×10^{-4}**	**100%**

TCEQ, 2011

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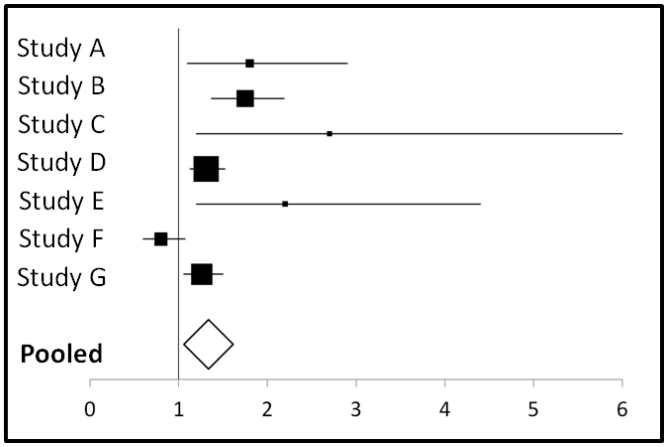
Meta-analysis Opportunities



- Rigorous, adaptable tool for systematic data review
- Both specific results and process yield insights
- Advances from improved use of existing tools and methods
- Many opportunities exist for expanded applications
  - Existing data and research areas
  - New data types
  - Multi-faceted evaluations
  - Policy

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Questions?

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