Accountability and Attribution: Origin and Applications

Jonathan M. Samet, MD, MS
Distinguished Professor and Flora L. Thornton Chair
Department of Preventive Medicine
USC Keck School of Medicine

HEI Annual Conference
May 1, 2017

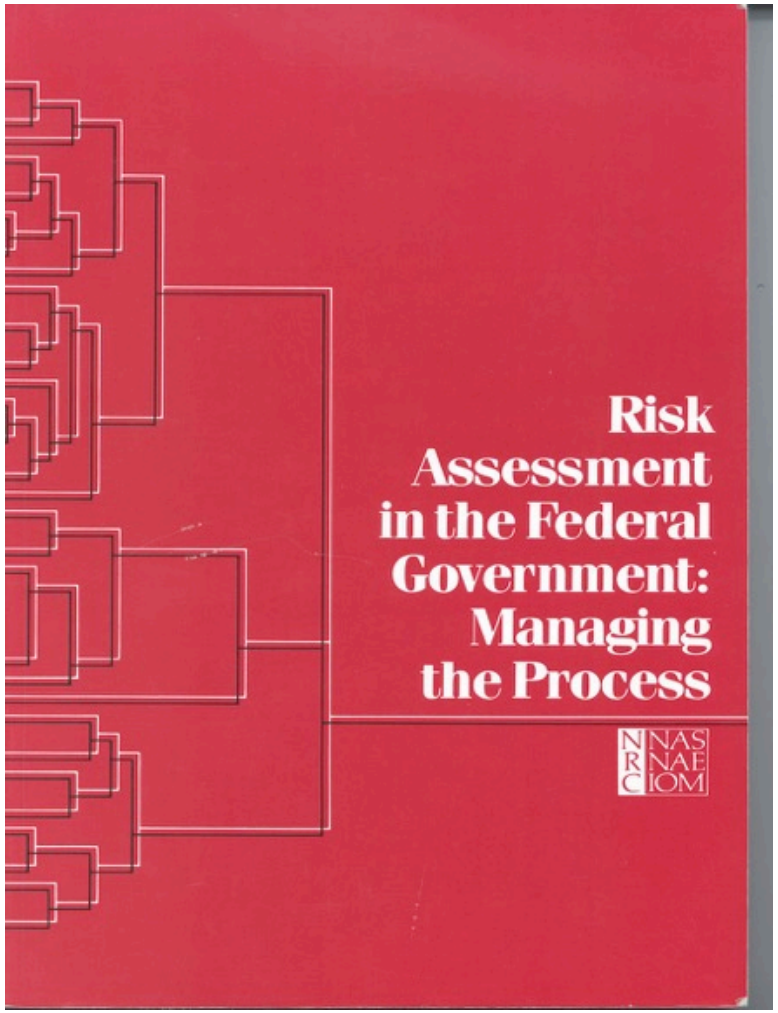
Morton Levin's Attributable Risk Formula

Johns Hopkins School of Hygiene and Public Health, Department of Epidemiology, c. 1935-36

- Estimate the Relative Risk (RR)
- Estimate the prevalence (P) of each risk factor.
- Calculate population attributable risk (PAR)

$$PAR = \frac{P(RR - 1)}{1 + P(RR - 1)}$$

The “Red Book”



Elements of Quantitative Risk Assessment (QRA)

Hazard ID
Dose-response
Exposure assessment
Risk characterization

Applications

SAMMEC

Smoking-Attributable Mortality, Morbidity, and Economic Costs

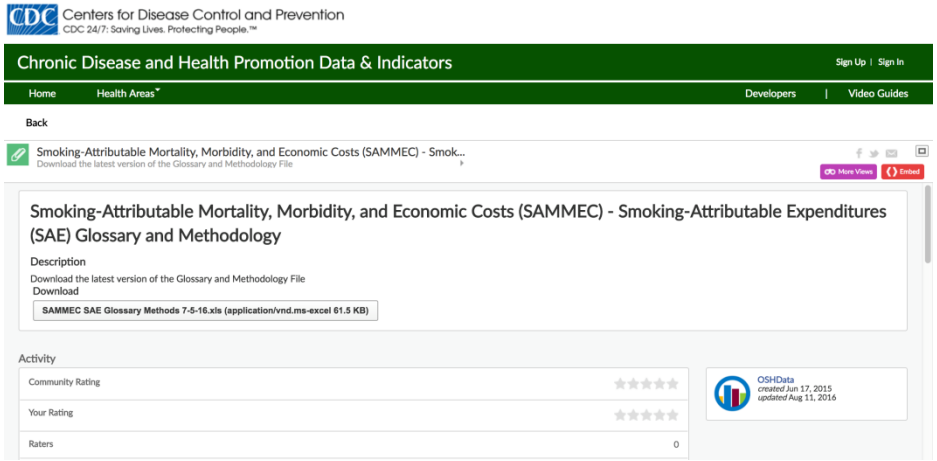


Table 12.4 Annual deaths and estimates of smoking-attributable mortality (SAM) for adults 35 years of age and older, total and by gender, United States, 2005–2009

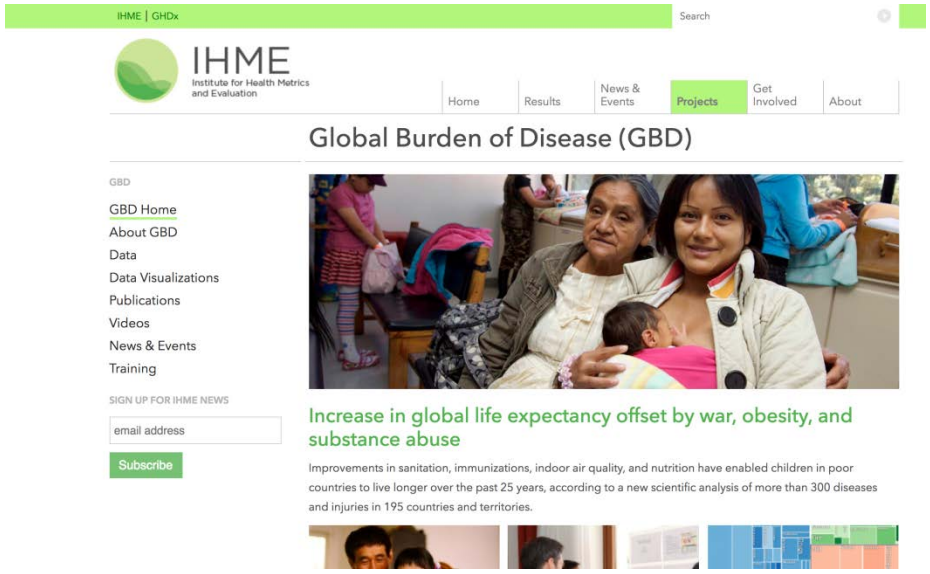
	Males			Females			Total	
Disease	**Deaths**	**SAM**	**Attributable fraction (%) Deaths**	**SAM**	**Attributable fraction (%) Deaths**	**SAM**	**SAM**	**Attributable fraction (%)**
Lung cancer	88,730	74,300	83.74	69,800	56,359	80.74	158,530	130,659	82.42
Other cancers[a]	102,940	26,000	25.26	75,540	10,000	13.24	178,480	36,000	20.17
Total—Cancers	**191,670**	**100,300**	**52.33**	**145,340**	**63,400**	**43.62**	**337,010**	**163,700**	**48.57**
Coronary heart disease	218,870	61,800	28.24	193,720	37,500	19.36	412,590	99,300	24.07
Other heart disease[b]	75,670	13,400	17.71	96,200	12,100	12.58	171,870	25,500	14.84
Cerebrovascular disease[c]	53,610	8,200	15.30	81,300	7,100	8.73	134,920	15,300	11.34
Other vascular disease[d]	14,480	6,000	41.43	15,510	5,500	35.47	29,990	11,500	38.35
Diabetes mellitus	35,200	6,200	17.61	35,600	2,800	7.86	70,810	9,000	12.71
Total—Cardiovascular and metabolic diseases	**397,840**	**95,600**	**24.03**	**422,330**	**65,000**	**15.39**	**820,170**	**160,600**	**19.58**
Pneumonia, influenza, tuberculosis	25,300	7,800	30.83	30,290	4,700	15.52	55,590	12,500	22.49
COPD	61,430	50,400	82.04	66,300	50,200	75.71	127,740	100,600	78.76
Total—Pulmonary diseases[e]	**86,730**	**58,200**	**67.10**	**96,590**	**54,900**	**56.84**	**183,320**	**113,100**	**61.70**
Total—Cancers, cardiovascular and metabolic diseases, pulmonary diseases	**676,240**	**254,100**	**37.58**	**664,260**	**183,300**	**27.59**	**1,340,500**	**437,400**	**32.63**
Prenatal conditions[f]	5,970	346	5.80	4,620	267	5.78	10,590	613	5.79
Sudden infant death syndrome[g]	1,370	236	17.26	950	164	17.26	2,320	400	17.26
Perinatal conditions	**7,340**	**582**	**7.93**	**5,570**	**431**	**7.74**	**12,900**	**1,013**	**7.85**
Residential fires		**336**			**284**			**620**	**-**
Secondhand smoke									

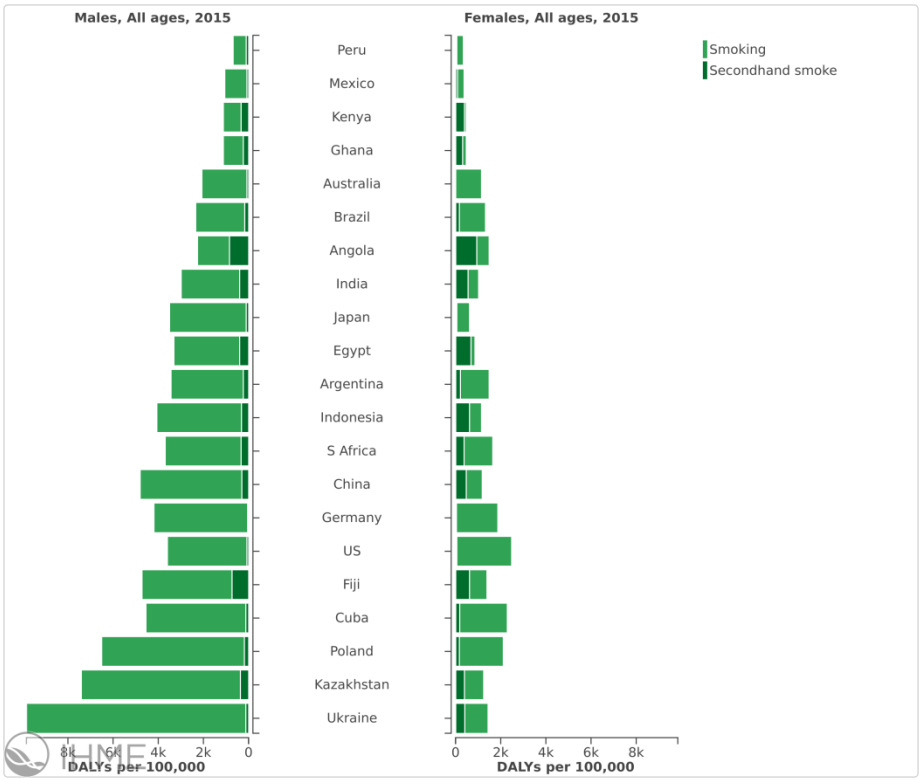
Source: https://www.ncbi.nlm.nih.gov/books/NBK294316/

Applications

GBD

Global Burden of Disease





Source: https://vizhub.healthdata.org/gbd-compare/

Applications

SAMMEC

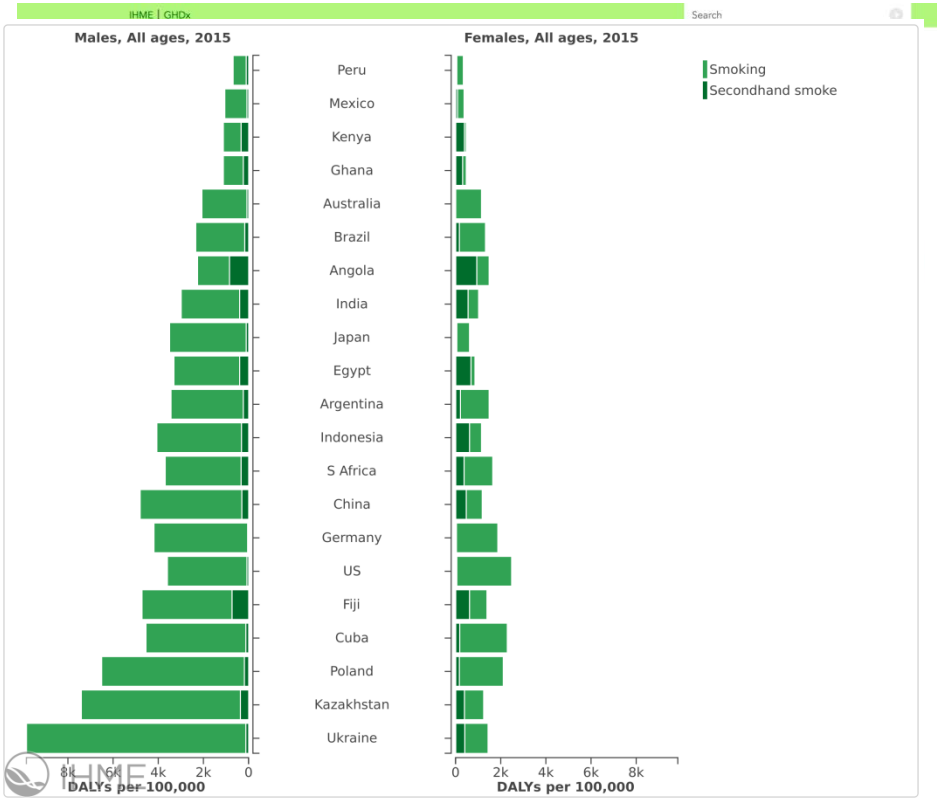
Smoking-Attributable Mortality, Morbidity, and Economic Costs

Table 12.4 Annual deaths and estimates of smoking-attributable mortality (SAM) for adults 35 years of age and older, total and by gender, United States, 2005–2009

	Males			Females			Total	
Disease	**Deaths**	**SAM**	**Attributable fraction (%)**	**Deaths**	**SAM**	**Attributable fraction (%)**	**SAM**	**Attributable fraction (%)**
Lung cancer	88,730	74,300	83.74	69,800	56,359	80.74	158,530	130,659	82.42
Other cancers[a]	102,940	26,000	25.26	75,540	10,000	13.24	178,480	36,000	20.17
Total—Cancers	**191,670**	**100,300**	**52.33**	**145,340**	**63,400**	**43.62**	**337,010**	**163,700**	**48.57**
Coronary heart disease	218,870	61,800	28.24	193,720	37,500	19.36	412,590	99,300	24.07
Other heart disease[b]	75,670	13,400	17.71	96,200	12,100	12.58	171,870	25,500	14.84
Cerebrovascular disease[c]	53,610	8,200	15.30	81,300	7,100	8.73	134,920	15,300	11.34
Other vascular disease[d]	14,480	6,000	41.43	15,510	5,500	35.47	29,990	11,500	38.35
Diabetes mellitus	35,200	6,200	17.61	35,600	2,800	7.86	70,810	9,000	12.71
Total—Cardiovascular and metabolic diseases	**397,840**	**95,600**	**24.03**	**422,330**	**65,000**	**15.39**	**820,170**	**160,600**	**19.58**
Pneumonia, influenza, tuberculosis	25,300	7,800	30.83	30,290	4,700	15.52	55,590	12,500	22.49
COPD	61,430	50,400	82.04	66,300	50,200	75.71	127,740	100,600	78.76
Total—Pulmonary diseases[e]	**86,730**	**58,200**	**67.10**	**96,590**	**54,900**	**56.84**	**183,320**	**113,100**	**61.70**
Total—Cancers, cardiovascular and metabolic diseases, pulmonary diseases	**676,240**	**254,100**	**37.58**	**664,260**	**183,300**	**27.59**	**1,340,500**	**437,400**	**32.63**
Prenatal conditions[f]	5,970	346	5.80	4,620	267	5.78	10,590	613	5.79
Sudden infant death syndrome[g]	1,370	236	17.26	950	164	17.26	2,320	400	17.26
Perinatal conditions	**7,340**	**582**	**7.93**	**5,570**	**431**	**7.74**	**12,900**	**1,013**	**7.85**
Residential fires		**336**			**284**			**620**	**-**
Secondhand smoke									

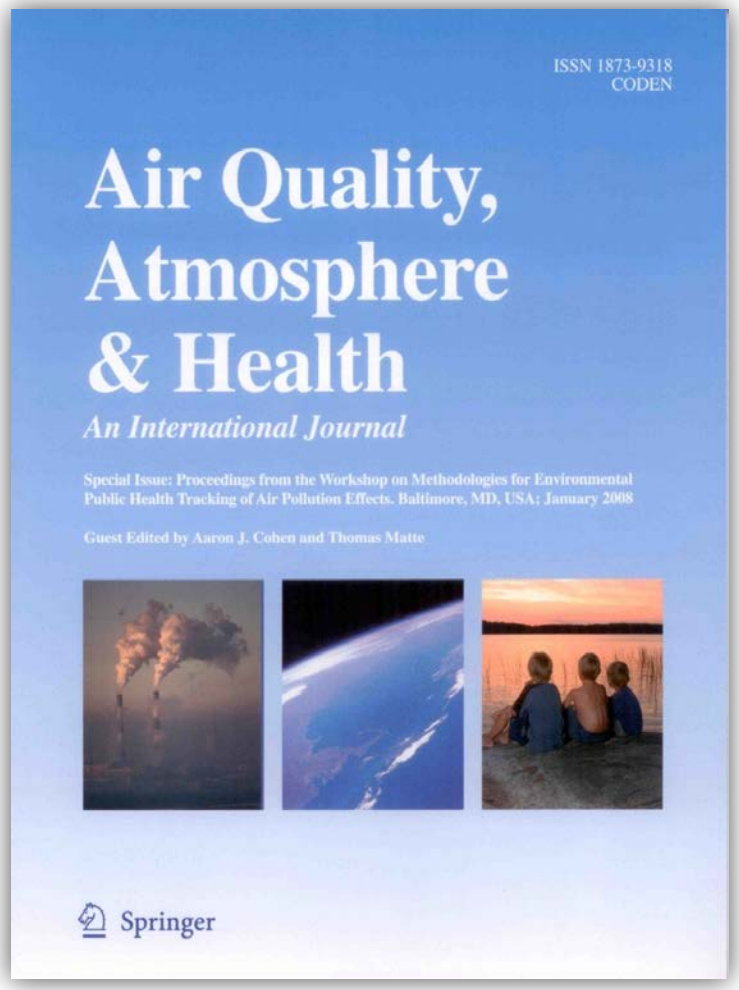
GBD

Global Burden of Disease



Sources: https://www.ncbi.nlm.nih.gov/books/NBK294316/; https://vizhub.healthdata.org/gbd-compare/

Environmental Public Health Tracking



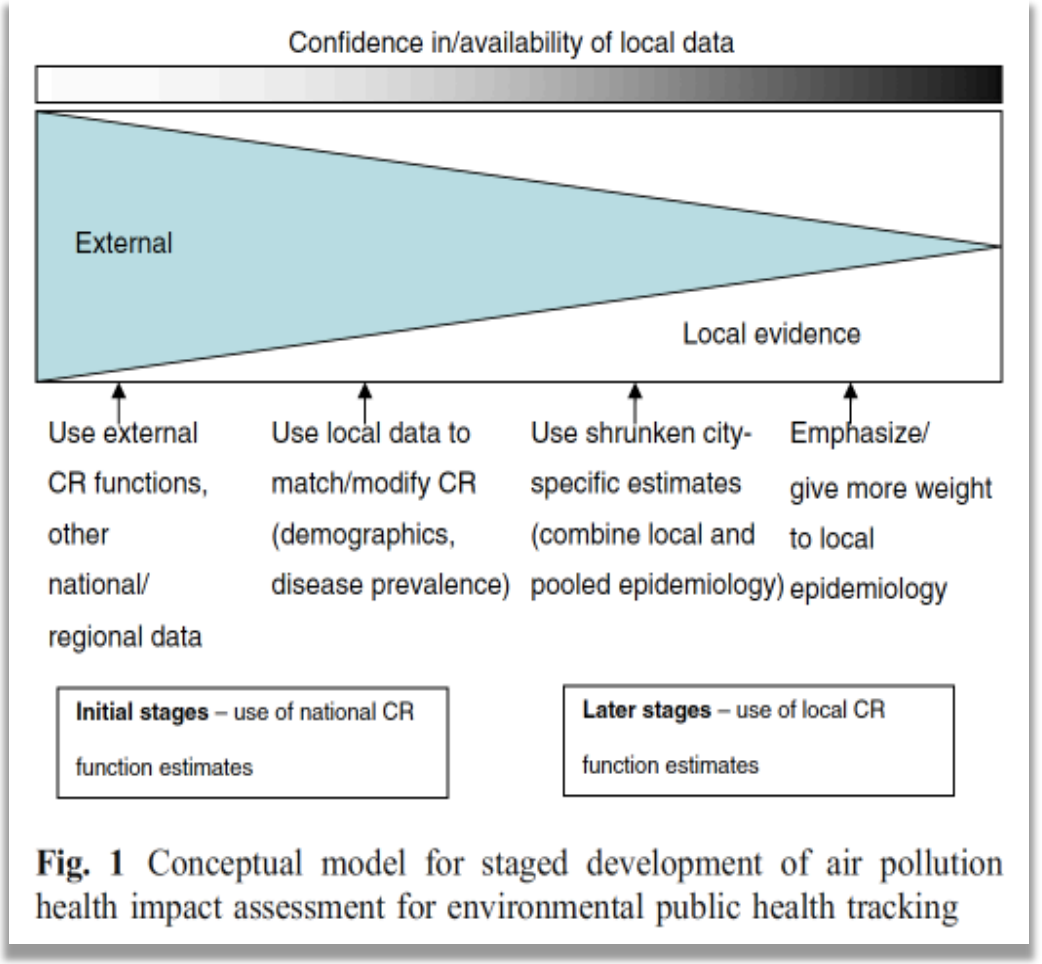


Fig. 1 Conceptual model for staged development of air pollution health impact assessment for environmental public health tracking

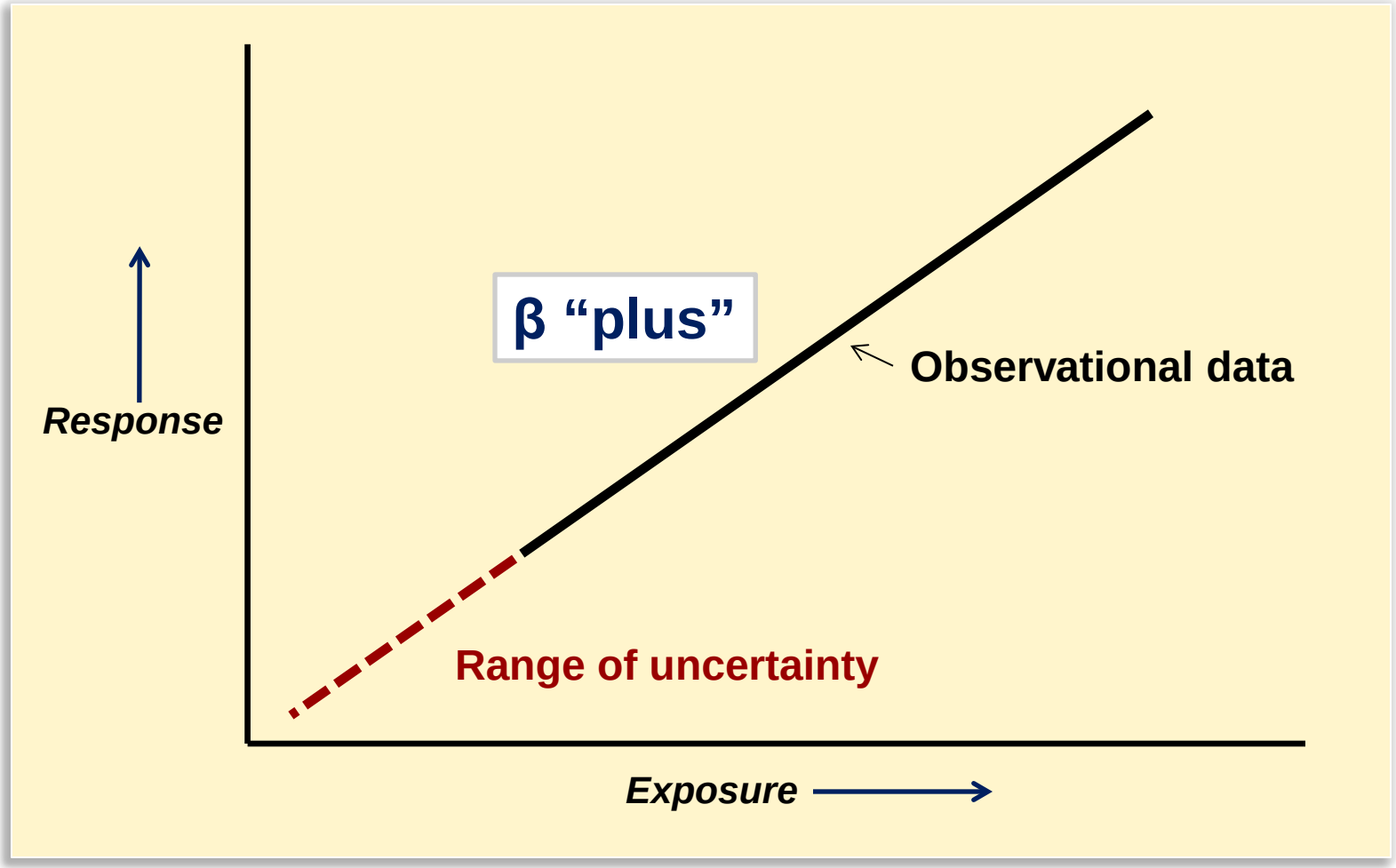
Available at: http://www.springerlink.com/content/1873-9326

Back to the beginning: Rationale for accountability studies

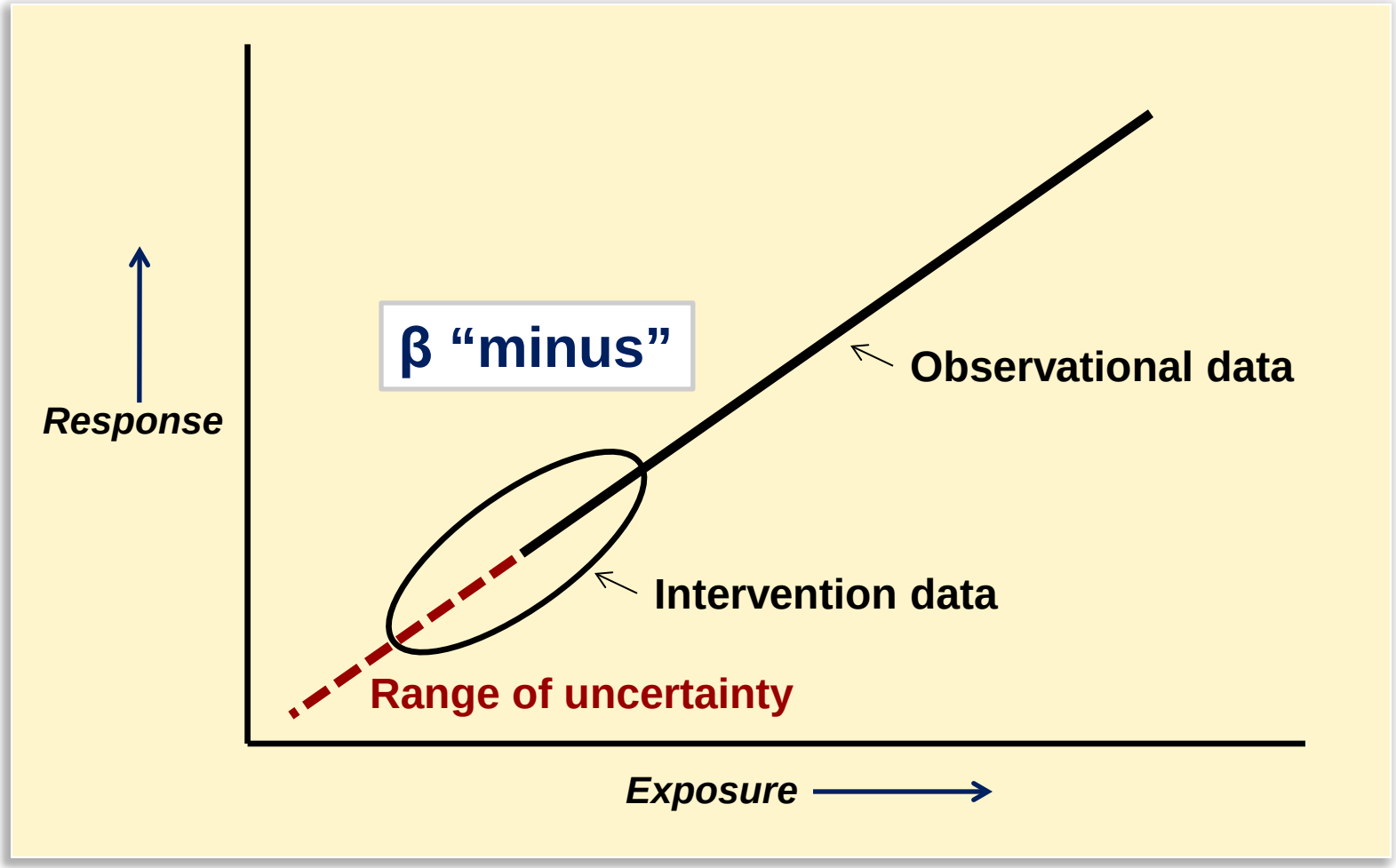
- There is (was) a call for it.
- Strengthen basis for causal inference (β+ vs. β-).
- Assess consequences of specific interventions.
- Provide “validation” of risk assessments.

+ and - refer to whether air pollutant concentrations are increasing (more emissions or higher-pollution location) or decreasing (intervention or clean air policies).

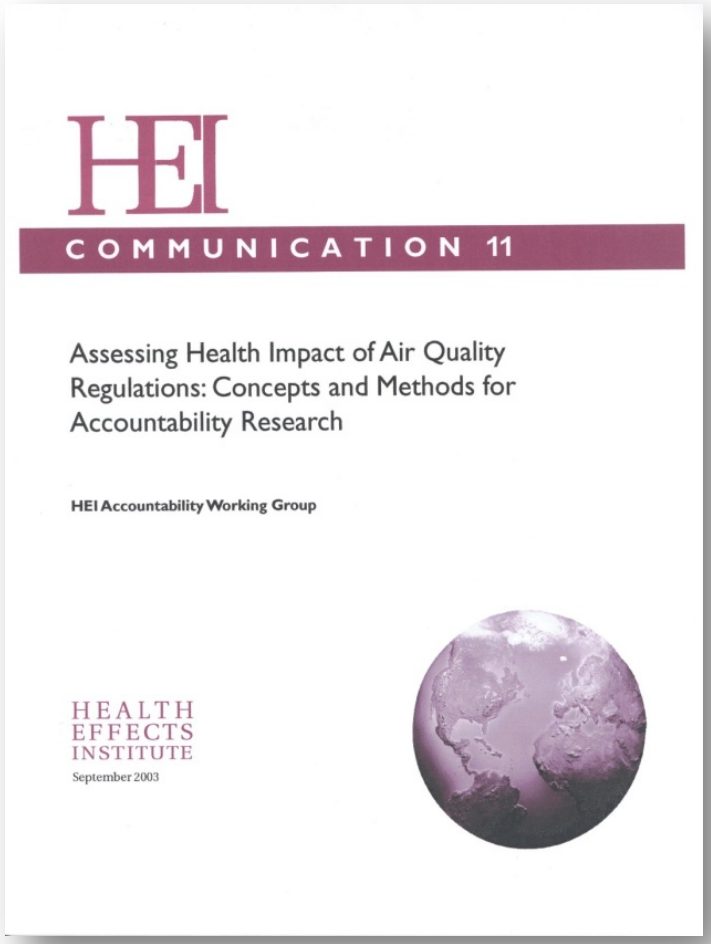
Interventions and Dose-Response



Interventions and Dose-Response

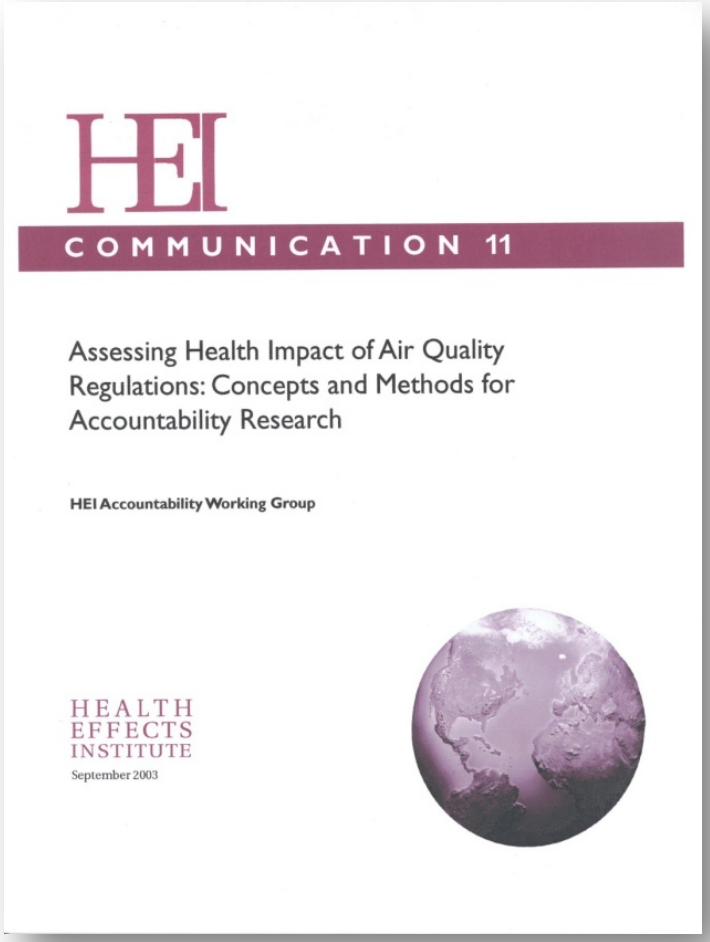


Accountability: Communication 11



"Evaluating the extent to which air quality regulations improve public health is part of a broad effort—termed ***accountability***—to assess the performance of all environmental regulatory policies."

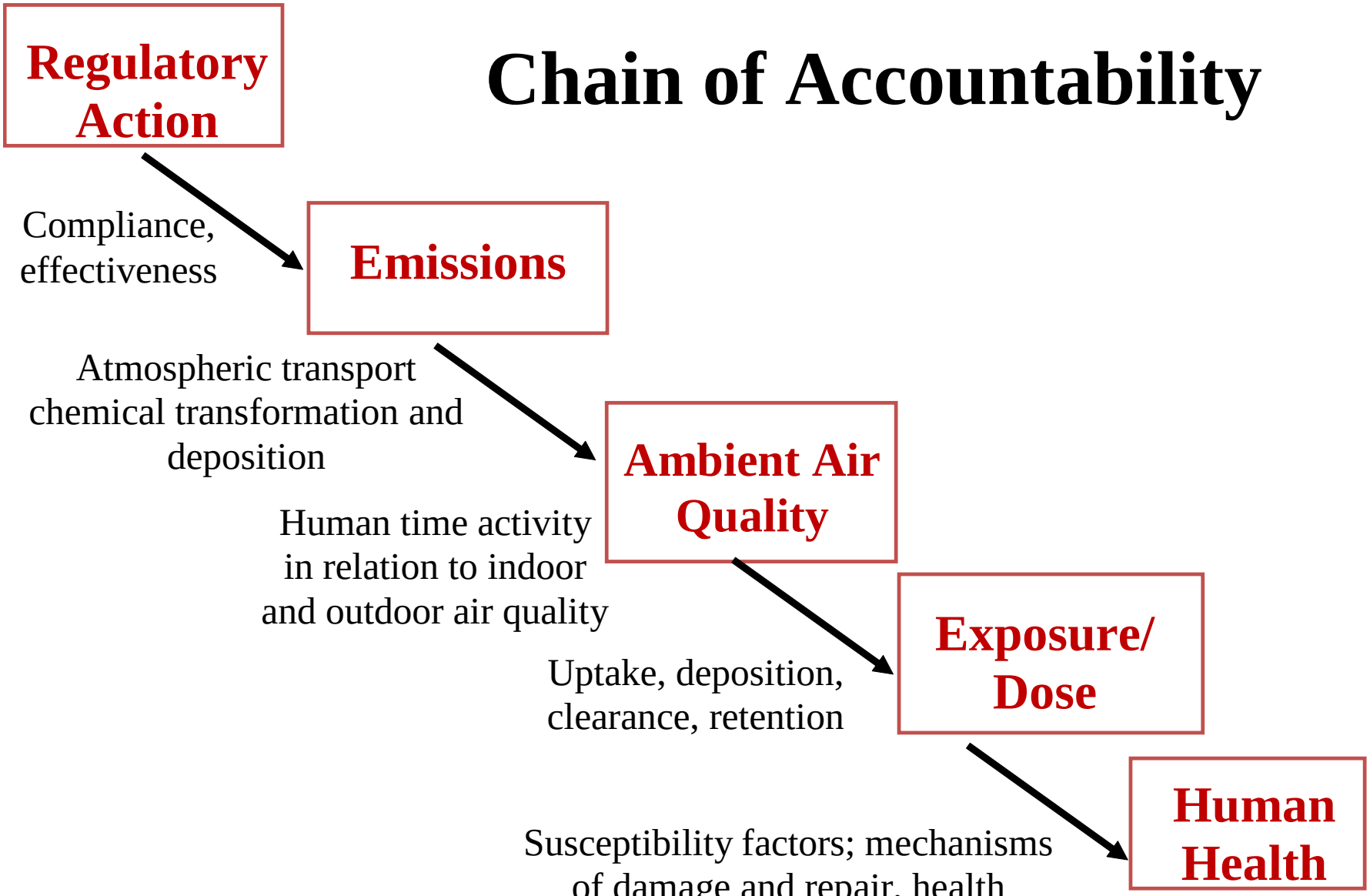
September, 2003



What did Communication 11 propose?

- Chain of accountability
- Conceptual framework
- Research recommendations

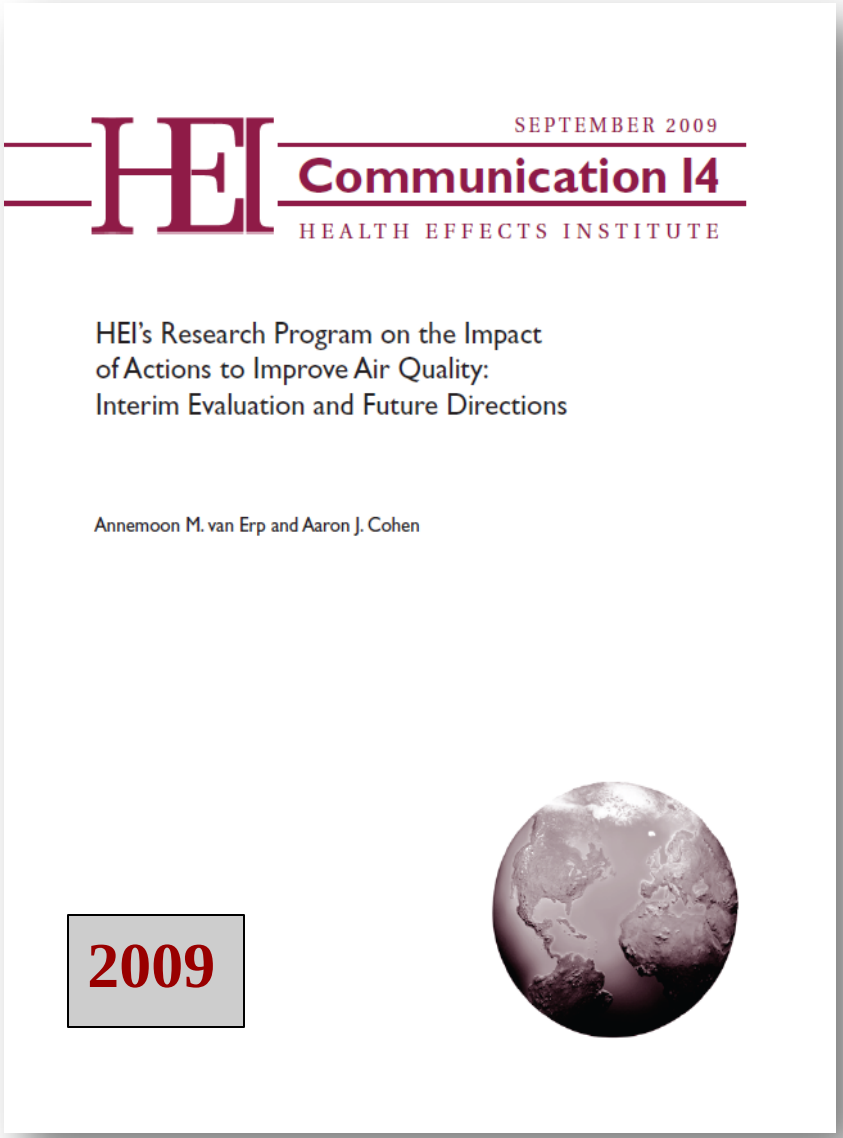
Chain of Accountability

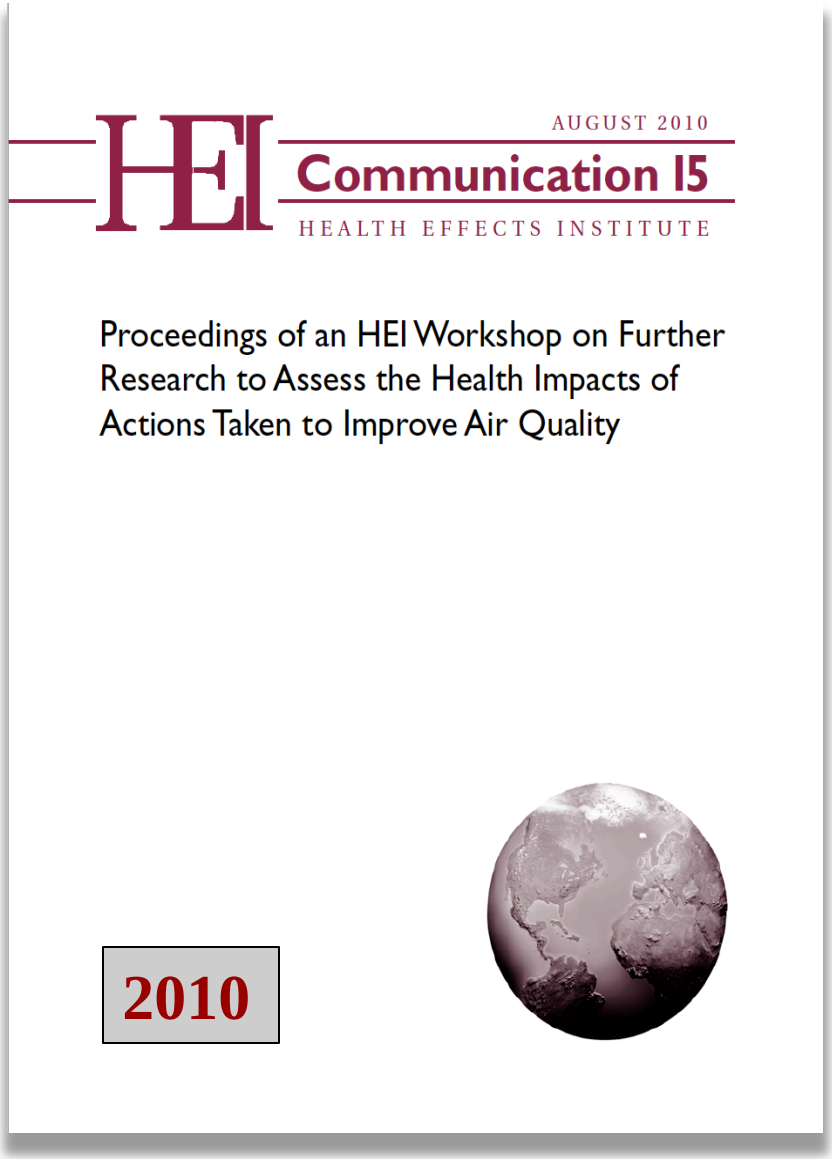


Communication 11: Recommendations

- Developing and implementing new study designs
- Identifying targets of opportunity
  - PM and O_3 NAAQS implementation
  - Air Toxics Control Plan
  - Targets at local level
- Developing surveillance systems

Accountability: Communications 14 and 15





Google accountability research air pollution Search Advanced Search

Web Show options... Results 1 - 10 of about 1,440,000 for accountability research air pollution. (0.21 seconds)

Tip: Save time by hitting the return key instead of clicking on "search"

Scholarly articles for accountability research air pollution

Particulate air pollution and mortality in the United ... - Dominici - Cited by 31
... perspectives on the public experience of air pollution - Bickerstaff - Cited by 53
... and bottom-up approaches to implementation research ... - Sabatier - Cited by 586

Accountability: Targets of Opportunity
Aug 26, 2004 ... Continually changing air pollution regulations in the United States, ... Accountability research concerning these air toxics might include ...
www.healtheffects.org/accountability.htm - Cached - Similar

Health Effects Institute - Home Page
Research Report 142, Air Pollution and Health: A European and North ... HEI publishes Evaluation of Accountability Research Program – September 2009 ...
www.healtheffects.org/ - Cached - Similar

Show more results from www.healtheffects.org

[PDF] US EPA: ACCOUNTABILITY RESEARCH: ASSESSING THE IMPACT OF AIR ...
File Format: PDF/Adobe Acrobat - Quick View
Accountability research in air science is inherently multidisciplinary. ... air pollution sciences that link sources to air quality as well as ...
www.epa.gov/airscience/pdf/ca-factsheet-accountability.pdf

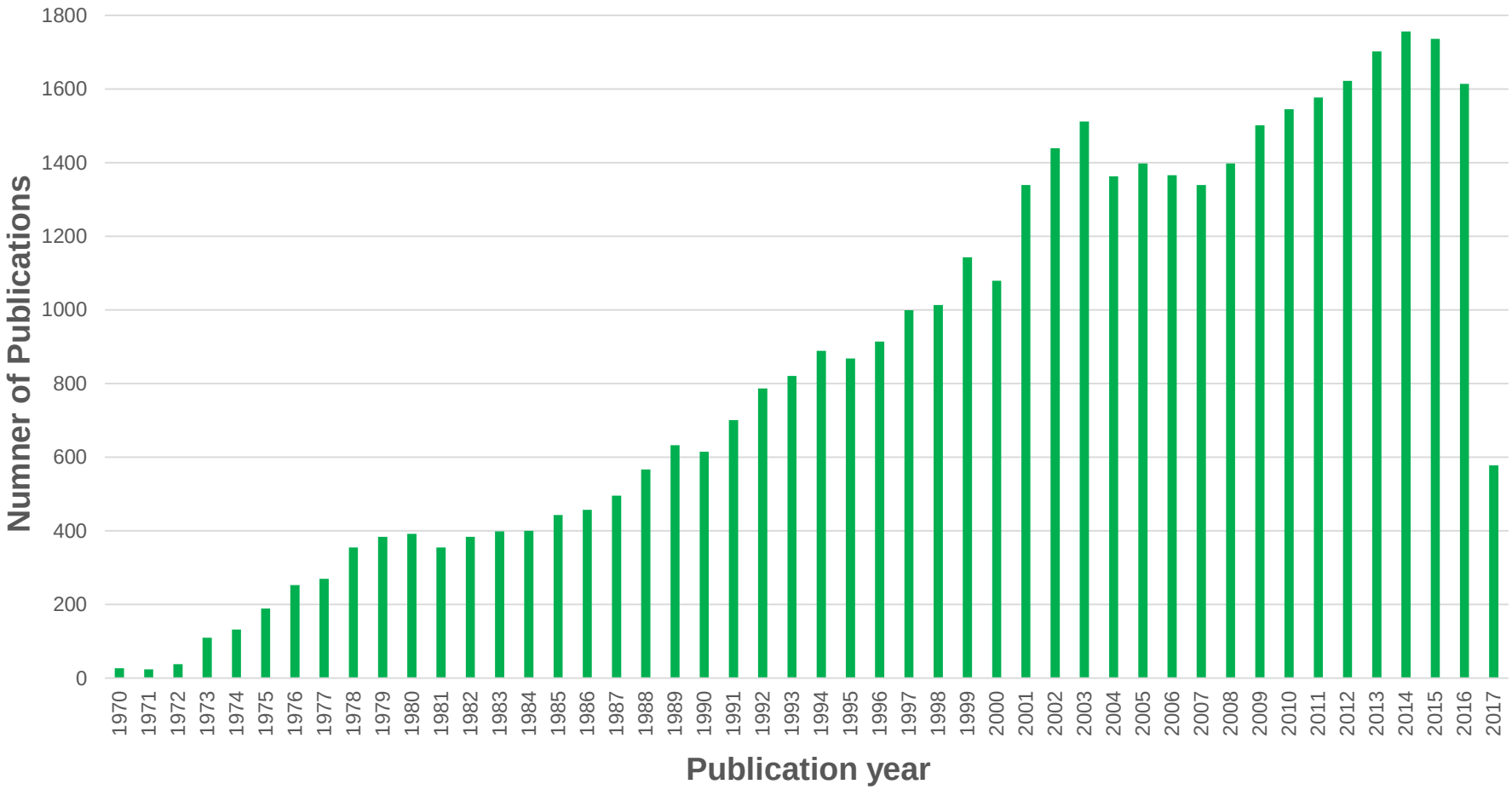
Air regulation support research | Research and Development | US EPA
US EPA: Accountability Research: Assessing the Impact of Air Quality Regulations ... Accountability research in air science is inherently multidisciplinary. ...
www.epa.gov/airscience/quick-finder/accountability.htm - Cached

Show more results from www.epa.gov

Multi-Pollutant Accountability
A meeting of Lead Authors for the NARSTO multi-pollutant accountability assessment was held in Research Triangle Park, North Carolina. ... A workshop on modeling issues in multi-pollutant air quality management was held in Denver on ...
www.narsto.org/mpacc.src - Cached - Similar

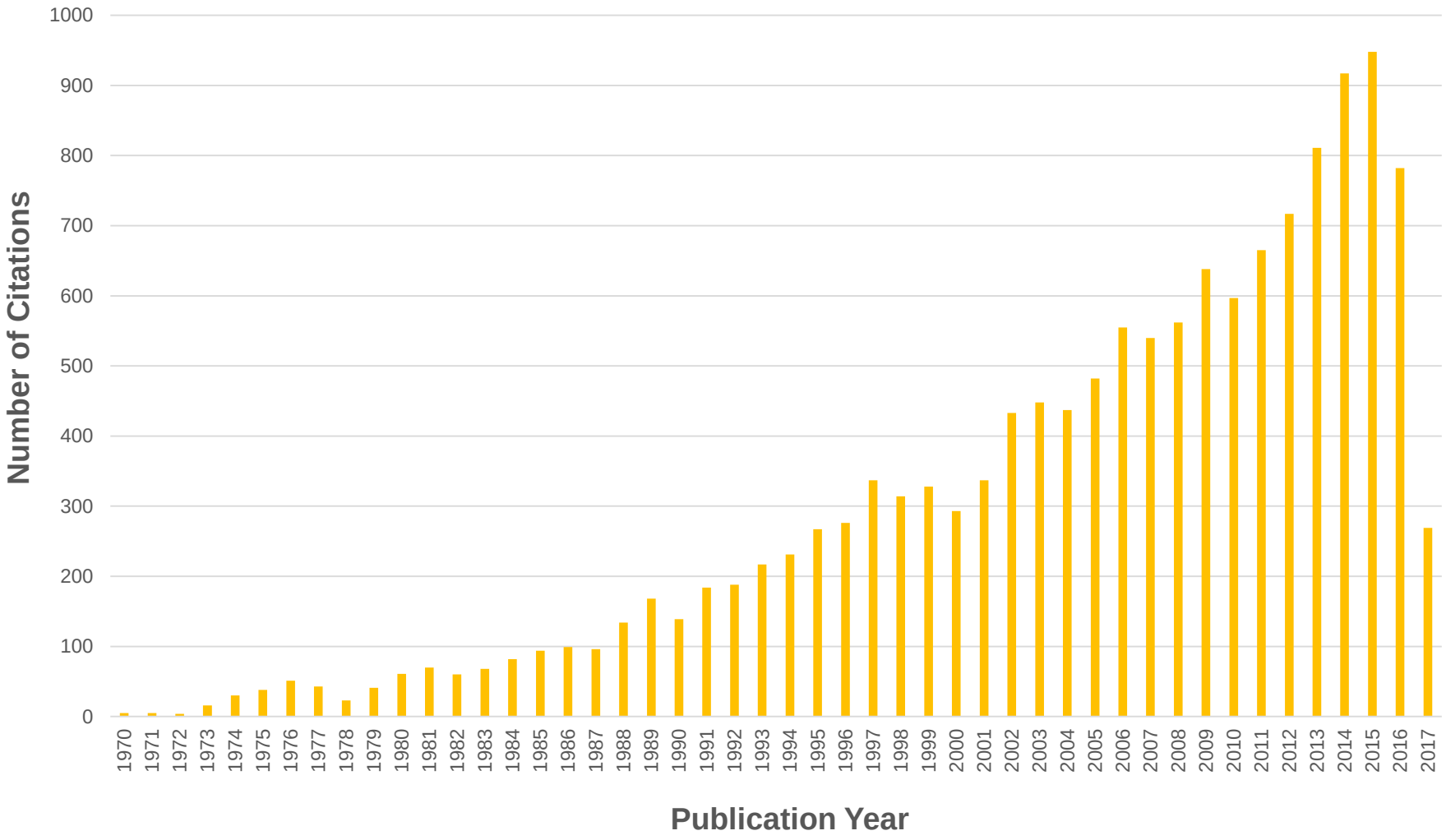
NEJM -- Evaluating the Effects of Ambient Air Pollution on Life ...
by D Krewski - 2009 - Cited by 2 - Related articles
Jan 5, 2009 ... Air pollution is an important determinant of population health. .... quality regulations: concepts and methods for accountability research. ...
content.nejm.org/cgi/content/full/360/4/413 - Similar

PubMed Analysis: Accountability



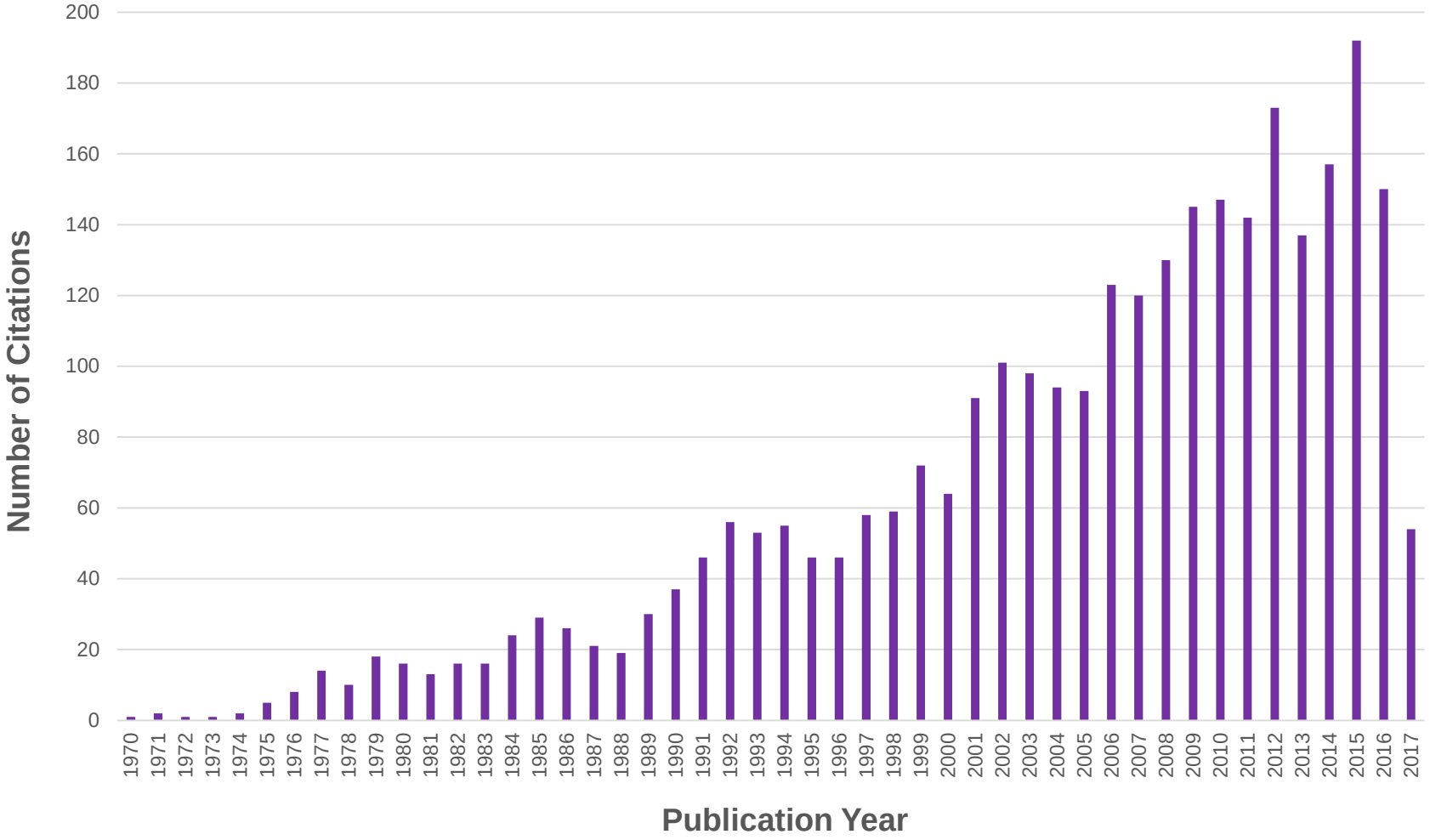
Search terms: "social responsibility"[MeSH Terms] OR ("social"[All Fields] AND "responsibility"[All Fields]) OR "social responsibility"[All Fields] OR "accountability"[All Fields]

PubMed Analysis: Accountability AND Research



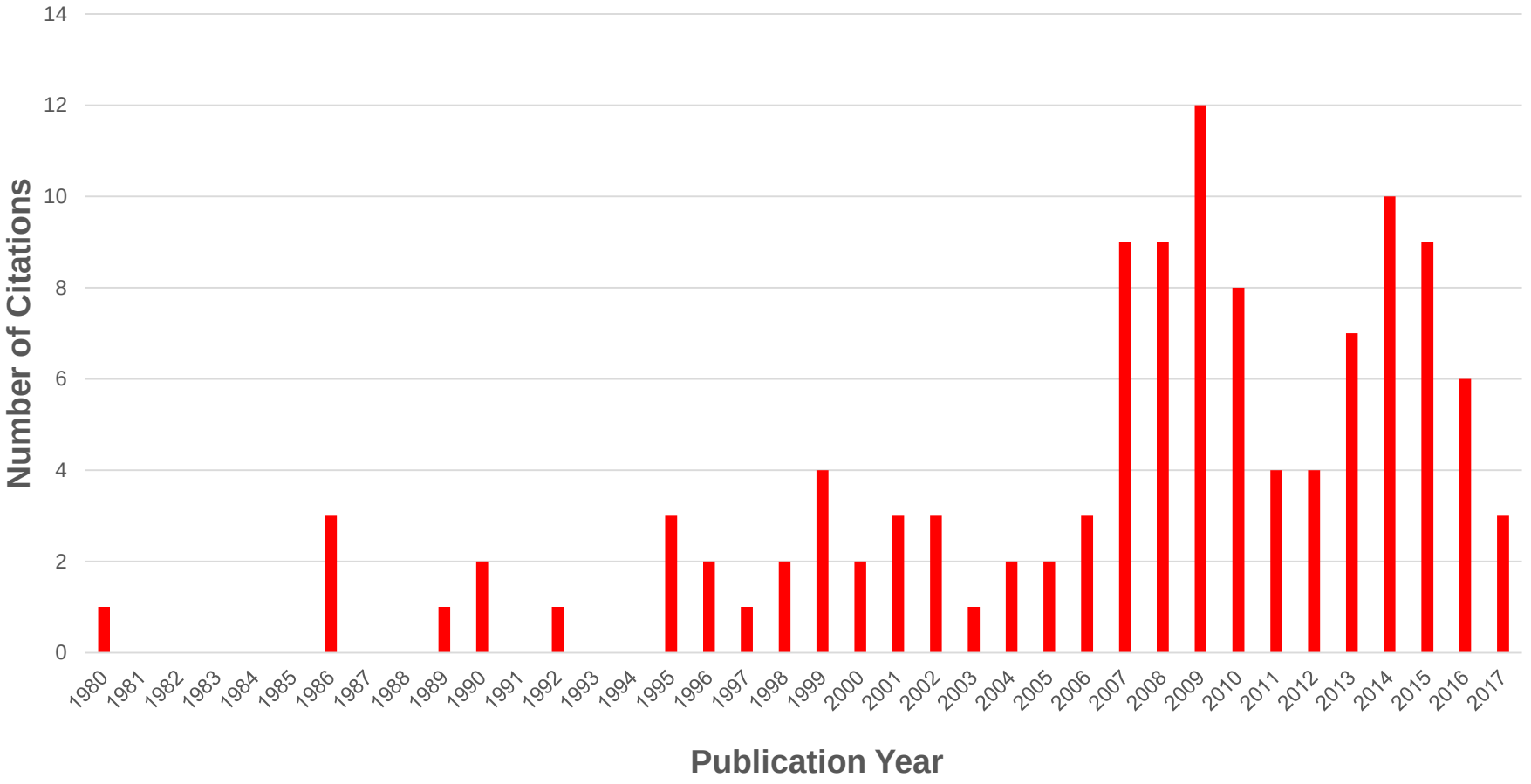
Search terms: ("social responsibility"[MeSH Terms] OR ("social"[All Fields] AND "responsibility"[All Fields]) OR "social responsibility"[All Fields] OR "accountability"[All Fields]) AND ("research"[MeSH Terms] OR "research"[All Fields])

PubMed Analysis: Accountability AND Environment



Search terms: ("social responsibility"[MeSH Terms] OR ("social"[All Fields] AND "responsibility"[All Fields]) OR "social responsibility"[All Fields] OR "accountability"[All Fields]) AND ("environment"[MeSH Terms] OR "environment"[All Fields])

PubMed Analysis: Accountability AND Air Pollution



Search terms("social responsibility"[MeSH Terms] OR ("social"[All Fields] AND "responsibility"[All Fields]) OR "social responsibility"[All Fields] OR "accountability"[All Fields]) AND ("air pollution"[MeSH Terms] OR ("air"[All Fields] AND "pollution"[All Fields]) OR "air pollution"[All Fields])

Respiratory Disease Associated with Community Air Pollution and a Steel Mill, Utah Valley

AJPH 1989; 79 (5): 623-8

C. Arden Pope III, PhD

Abstract: This study assessed the association between hospital admissions and fine particulate pollution (PM_{10}) in Utah Valley during the period April 1985–February 1988. This time period included the closure and reopening of the local steel mill, the primary source of PM_{10}. An association between elevated PM_{10} levels and hospital admissions for pneumonia, pleurisy, bronchitis, and asthma was observed. During months when 24-hour PM_{10} levels exceeded 150 $\mu g/m^3$, average admissions for children nearly tripled; in adults, the increase in admissions was 44 per cent. During months with mean PM_{10} levels greater than or equal to 50 $\mu g/m^3$ average admissions for children and adults increased by 89 and 47 per cent, respectively. During the winter months when the steel mill was open, PM_{10} levels were nearly double the levels experienced during the winter months when the mill was closed. This occurred even though relatively stagnant air was experienced during the winter the mill was closed. Children's admissions were two to three times higher during the winters when the mill was open compared to when it was closed. Regression analysis also revealed that PM_{10} levels were strongly correlated with hospital admissions. They were more strongly correlated with children's admissions than with adult admissions and were more strongly correlated with admissions for bronchitis and asthma than with admissions for pneumonia and pleurisy. (*Am J Public Health* 1989; 79:623–628.)

Introduction

On March 20, 1984, the US Environmental Protection Agency (EPA) proposed changes in the national ambient air quality standards for particulate pollution. Total suspended particulates (TSP) was to be replaced with a new indicator of particulate pollution that includes only those particulates with an aerodynamic diameter equal to or less than a nominal 10 micrometers (PM_{10}). On July 1, 1987, the EPA announced its final decision. The previous primary TSP standards were to be replaced, effective July 31, 1987, with a 24-hour PM_{10} standard of 150 micrograms per cubic meter ($\mu g/m^3$) with no more than one expected exceedance per year and an annual

Methods

Study Area

Utah Valley, located in Utah County of Central Utah, is the third largest county in the state with a population of 258,000 in 1987.[24] Approximately two-thirds of the population resides in five nearly contiguous cities situated on a valley floor with an elevation of approximately 1,402 meters above sea level bordered east and west by mountains (Figure 1).

Based on an unpublished 1986 Utah State Department of Health survey, only 5.5 per cent of Utah County's adults (18 years of age or older) smoke; approximately 90 per cent of its

Respiratory Disease Associated with Community Air Pollution and a Steel Mill, Utah Valley

AJPH 1989; 79 (5): 623-8

C. Arden Pope III, PhD

Abstract: This study assessed the association between hospital admissions and fine particulate pollution (PM_{10}) in Utah Valley during the period April 1985–February 1988. This time period included the closure and reopening of the local steel mill, the primary source of PM_{10}. An association between elevated PM_{10} levels and hospi… was o… 150 μg… the in… PM_{10} … childr… Durin…

Intro…

Agen… qualit… partic… partic… with an aerodynamic diameter equal to or less than a nominal 10 micrometers (PM_{10}). On July 1, 1987, the EPA announced its final decision. The previous primary TSP standards were to be replaced, effective July 31, 1987, with a 24-hour PM_{10} standard of 150 micrograms per cubic meter ($\mu g/m^3$) with no more than one expected exceedance per year and an annual

were … when … stagna… Childr… winte… Regre… correl… correl… were … asthm… *Publi…*

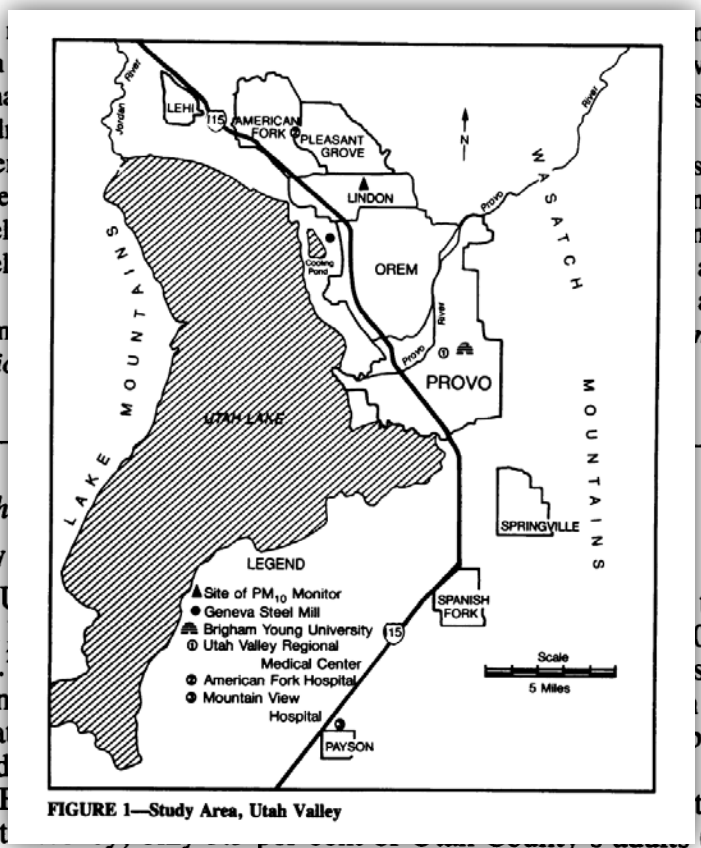


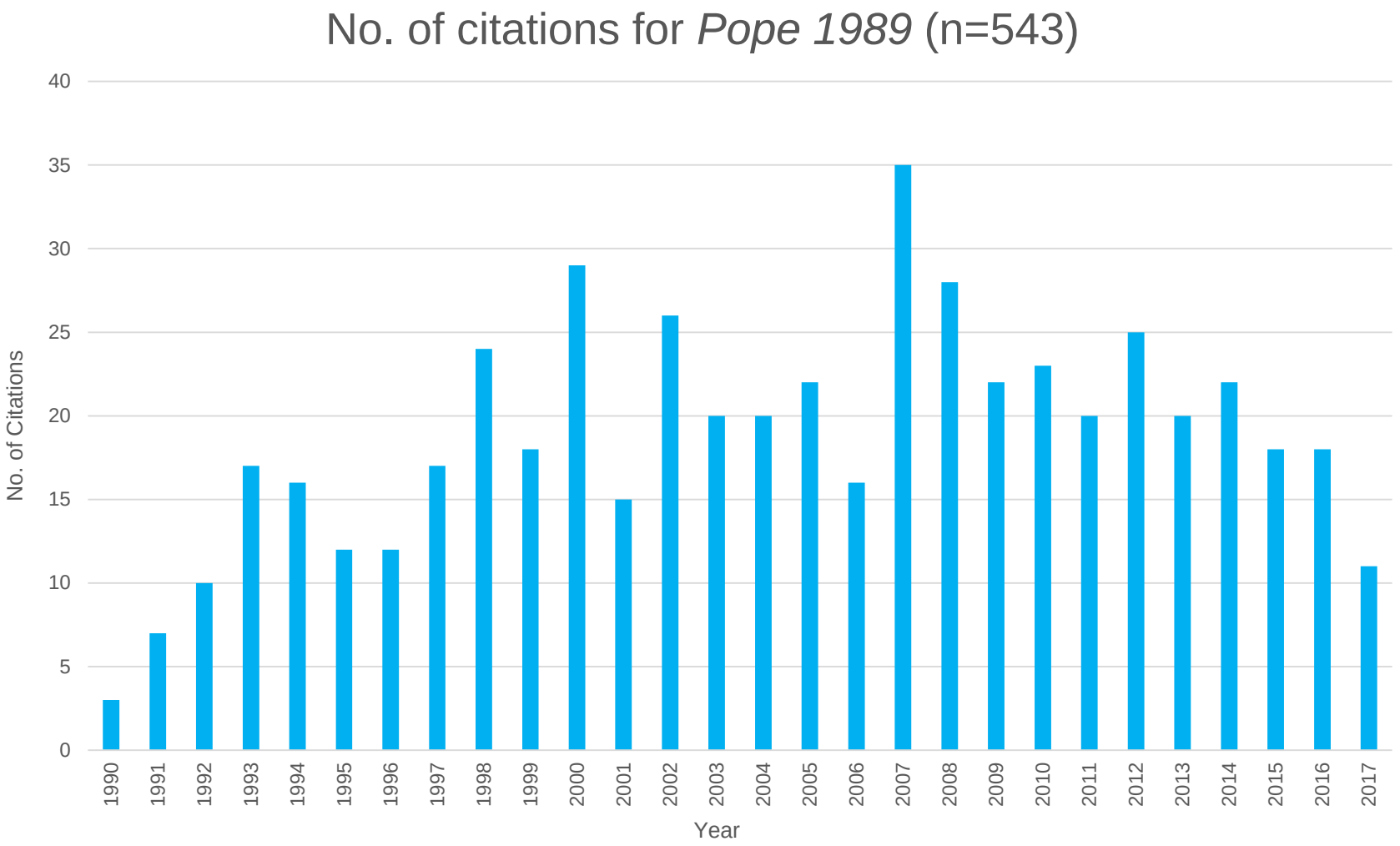
FIGURE 1—Study Area, Utah Valley

Meth…

Study …

third … 1987. … five n… eleva… dered…

Healt… years of age or older) smoke; approximately 90 per cent of its



Pope CA 3rd. Respiratory disease associated with community air pollution and a steel mill, Utah Valley. AJPH 1989 May;79(5):623-8.

Data from Google Scholar

EPA United States Environmental Protection Agency

October 2004
EPA/600/P-99/002aF

Air Quality Criteria for Particulate Matter

U.S. EPA. Air Quality Criteria for Particulate Matter (Final Report, Oct 2004). U.S. Environmental Protection Agency, Washington, DC, EPA 600/P-99/002aF-bF, 2004

Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

8.2.3.4 PM-Mortality Intervention Studies

Although many studies have reported short-term associations between PM indices and mortality, a largely unaddressed question remains as to the extent to which reductions in ambient air PM actually lead to reductions in deaths attributable to PM. This question is not only important in terms of "accountability" from the regulatory point of view, but it is also a scientific question that challenges the predictive validity of statistical models and their underlying assumptions used thus far to estimate excess mortality due to ambient PM.

The opportunities to address this question are rare. However, at the time of the 1996 PM AQCD, one situation presented a good opportunity for a PM intervention study—that being the Utah Valley situation evaluated by Pope. In the Pope (1989) analysis of PM_{10} and children's hospital admissions in Utah Valley, the study period contained the 13-month steel mill closure mentioned earlier (during which time PM_{10} concentrations averaged 35 $\mu g/m^3$ versus 50 $\mu g/m^3$ when the mill was opened). Analyses of children's respiratory admissions in Utah Valley before and after the steel mill closure provided evidence of decreased morbidity resulting from the lower PM_{10} concentrations during the mill closure.

Two more recent mortality intervention studies have examined: (1) the impact of a ban on coal sale in Dublin, Ireland (Clancy et al., 2002); and (2) the impact of a regulation to use fuel oil with low sulfur content in Hong Kong (Hedley et al., 2002). These regulations were enforced

Integrated Science Assessment for Particulate Matter

The objective of the Dominici et al. (2007, 097361) study described above was motivated by accountability research, the idea of measuring the impact of policy interventions. However, unlike the intervention studies conducted in Hong Kong (Hedley et al., 2002, 040284) and Dublin, Ireland (Clancy et al., 2002, 035270) that were reviewed in the 2004 PM AQCD (U.S. EPA, 2004, 056905), this study was not designed to estimate a reduction in mortality in response to a sudden change in air pollution. In fact, the figure of observed trend in PM_{10} levels presented in the Dominici et al. (2007, 097361) study indicates that the decline in PM_{10} levels during the study period was very gradual, with much of the decline appearing in the first few years (median values of ~33 $\mu g/m^3$ in 1987 to ~25 $\mu g/m^3$ in 1992, then down to ~23 $\mu g/m^3$ in 2000). A flaw in the use of the time-series study design for this type of analysis is that it adjusts for long-term trends, and, therefore, does not estimate the change in mortality in response to the gradual change in PM_{10}. The apparent change, though weak, in the PM_{10} risk estimates may also reflect a potential change in the composition of PM_{10} (i.e., $PM_{10-2.5}$ or $PM_{2.5}$). The study listed a number of PM_{10}-related air pollution control programs that were implemented between 1987 and 2000. Some of these programs, such as the Acid Rain Control Program, did result in major reductions in emissions, and, therefore, could have contributed to the results observed, but the analytic approach used in the study does not allow for a systematic analysis of the effect of air pollution policies on the risk of mortality.

United States Environmental Protection Agency

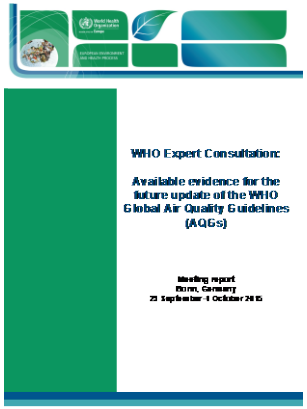
December 2009
EPA/600/R-08/139F

Integrated Science Assessment for Particulate Matter

Includes Errata Sheet created on 2/10/2010

U.S. EPA. Air Quality Criteria for Particulate Matter (Final Report, Dec 2009). U.S. Environmental Protection Agency, Washington, DC, EPA 600/R-08/139F, 2009

Available at: https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=216546

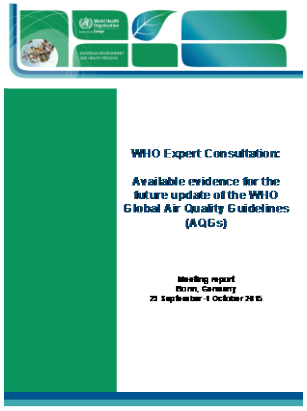


5. Interventions in the context of AQGs

Previous editions of the AQGs have mainly focussed on providing guidance in the form of pollutant-exposure specific recommendations, usually as 'not to be exceeded' concentration levels of air pollutants. Some informative text on application of guidelines in policy formulation, including risk management and implementation of the guidelines, has also been proposed; however this has largely been done without a systematic review of the underlying scientific evidence evaluating their effectiveness.

For the next update of the guidelines, it may be possible to formulate recommendations concerning specific measures or interventions shown to decrease the levels of air pollutants and improve health. These recommendations could be useful to countries, policy makers or other end-users of the guidelines on how to progress towards meeting the WHO goals. If and to what extent the available scientific evidence justifies including this particular topic as part of the updated AQGs was discussed during the third day of the expert meeting.

Jacob Burns from the University of Munich presented the study design and preliminary results of an ongoing Cochrane systematic review, conducted in collaboration with researchers from the Health Effects Institute (HEI), assessing the effectiveness of interventions in improving air quality (mostly $PM_{2.5}$ and PM_{10}) and/or health effects. This review includes evidence from 47 studies in 18 countries across the world, categorized according to the source of PM as vehicular, industrial, residential or multiple sources; and assesses the effect of these interventions on both non-health (i.e. mainly changes in pollutant concentrations) and health outcomes (i.e. mortality, hospital admissions due to cardiovascular or respiratory events, emergency department admissions and pre-term birth weight). Modelling studies were not included in the review as the project did not have the scope to evaluate the quality of the models.



5. Interventions in the context of AQGs

Previous editions of the AQGs have mainly focussed on providing guidance in the form of pollutant-exposure specific recommendations, usually as 'not to be exceeded' concentration levels of air pollutants. Some informative text on application of guidelines in policy formulation, including risk management and implementation of the guidelines, has also been proposed; however this has largely been done without a systematic review of the underlying scientific evidence evaluating their effectiveness.

For the next update of the guidelines, it may be possible to formulate recommendations concerning specific measures or interventions shown to decrease the levels of air pollutants and improve health. These recommendations could be useful to countries, policy makers or other end-users of the guidelines on how to progress towards meeting the WHO goals. If and to what extent the available scientific evidence justifies including this particular topic as part of the updated AQGs was discussed during the third day of the expert meeting.

$PM_{2.5}$ and PM_{10}) and/or health effects. This review includes evidence from 47 studies in 18 countries across the world, categorized according to the source of PM as vehicular, industrial, residential or multiple sources; and assesses the effect of these interventions on both non-health (i.e. mainly changes in pollutant concentrations) and health outcomes (i.e. mortality, hospital admissions due to cardiovascular or respiratory events, emergency department admissions and pre-term birth weight). Modelling studies were not included in the review as the project did not have the scope to evaluate the quality of the models.

Has accountability been useful?

- For developing a research agenda?
- For providing evidence that is useful for evidence-based regulation?
- For benefitting public health?

Who Knew

That accountability could be so complicated?