

Supplemental Resources for EHEA Annotated Bibliography

Introduction

This document includes a list of supplemental resources for the [NIEHS Environmental Health Economic Analysis \(EHEA\) Annotated bibliography](#). These supplemental resources are meant to provide environmental health researchers additional information about economic analyses, such as applicable economic methods and models. The list also contains resources in which researchers evaluated economic and/or health variables in a location outside of the U.S. The articles, gray literature, and books or book chapters included in the list focus on exposures and diseases relevant to NIEHS.

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Articles

Category: Health Economics, Methodology

Arrow KJ, Copper ML, Eads GC, Hahn RQ, Lave LB, Noll RG, Portney PR, Russell M, Schmalensee R, Smith VK, and Stavins RN. Is there a role for benefit-cost analysis in environmental health, and safety regulation? American Association for the Advancement of Science. 1996; 272(5259).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/8602504>

Article argues for the useful role of cost-benefit analysis in the environment, health, and safety regulatory process, and presents eight principles on the appropriate use of this type of analysis.

Bellavance F, Dionne G, and Lebeau M. The value of statistical life: A meta-analysis with a mixed effects regression model. Journal of Health Economics. 2009; 28(2).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/19100640>

DOI Link: <http://dx.doi.org/10.1016/j.jhealeco.2008.10.013>

Article presents a meta-analysis (using a mixed regression model) of the value of a statistical life (VSL), finding that the variability of VSL estimates found in the literature can be attributed to use of different methodologies, variables, and sample populations. It concludes that a willingness-to-pay method is most suitable for measuring individual preferences in matters of risk.

Chokshi DA and Farley TA. The cost-effectiveness of environmental approaches to disease prevention. N Engl J Med. 2012; 367(4).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/22830461>

DOI Link: <http://dx.doi.org/10.1056/NEJMp1206268>

This article compares the cost effectiveness ratio for three categories of preventative health care interventions by analyzing records in the Tufts Medical Center Cost-Effectiveness Analysis Registry. Environmental interventions were more likely to be cost effective than clinical interventions or person-directed interventions. Of the 59 cost-effective environmental interventions, 17% cost less than \$10,000 per quality-adjusted life-year (QALY), and 15% cost \$10,000 to \$50,000 per QALY. The author suggests that environmental interventions deserve more attention.

Curry J. Healthy, wealthy, and wise: Socioeconomic status, poor health in childhood, and human capital development. Journal of Economic Literature. 2009; 47(1).

URL: <http://www.jstor.org/stable/27647135>

This review article explored whether there are links between parental socioeconomic status (SES) and children's health, and whether children's health is related to their future education and labor market outcomes. The evidence supports links between SES status and children's health, and between health and future labor success. For example, low birth weight is associated with poorer adult health and lower adult earnings in several studies. The authors also suggest that the most sensitive developmental phase may be the prenatal period because recent evidence suggests that SES and environmental factors during pregnancy may influence their children's health and success as adults.

Doucouliaos C, Stanley TD, and Giles M. Are estimates of the value of a statistical life exaggerated. Journal of Health Economics. 2012; 31(1).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/22079490>

DOI Link: <http://dx.doi.org/10.1016/j.jhealeco.2011.10.001>

Article presents a meta-analysis examining the heterogeneity in the literature of the value of a statistical life (VSL) and finds that correcting for publication selection bias (i.e., the reduced probability that insignificant or negative VSL values are reported) reduces VSL estimates derived from hedonic wage-risk equations by 70-80%.

Farrow RS. A missing error term in benefit-cost analysis. Environmental Science and Technology. 2012.

URL: <http://www.ncbi.nlm.nih.gov/pubmed/22145927>

DOI Link: <http://dx.doi.org/10.1021/es202861z>

Article presents an implementable method to estimate the variance of random error and bounds and a framework for determining when such a variance estimate may be more useful than assuming zero error variance. Variance of error is typically omitted in benefit-cost models frequently used to inform environmental policy and management decisions, which can cause downward bias in any estimated forecast variance.

Freeman AM. Valuing environmental health effects - An economic perspective. Environmental & Resource Economics. 2006; 34.

DOI Link: <http://dx.doi.org/10.1007/s10640-006-9002-6>

Article provides an overview of some of the issues involved in comparing benefit-cost analysis and cost-effectiveness analysis based on quality-adjusted life years as alternative approaches to assessing environmental policies that affect human health.

Gao T, Wang XC, Chen R, Ngo HH and Guo W. Disability adjusted life year (DALY): a useful tool for quantitative assessment of environmental pollution. Sci Total Environ. 2015; 511.

URL: <http://www.ncbi.nlm.nih.gov/pubmed/25549348>

DOI Link: <http://dx.doi.org/10.1016/j.scitotenv.2014.11.048>

This article provides an overview of applicable methodologies and research directions for using disability adjusted life year (DALY) as a tool for quantitative assessment of environmental pollution. It introduces the methodological framework of DALY, and summarizes requirements for data collection and manipulation for quantifying disease burdens.

Gilbreath J. IOM: The economics of better environmental health. Environ Health Perspectives. 2007; 115(2).

URL: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817696/>

Article gives a broad overview of the different ways that costs of health benefits are calculated and some controversial aspects of this task, such as assigning monetary value to conditions and events like premature deaths.

Gollier C. Expected net present value, expected net future value, and the Ramsey rule. Journal of Environmental Economics and Management. 2010; 59(2).

URL: <http://www.sciencedirect.com/science/article/pii/S009506960900093X>

Paper discusses the three different discount rates approaches for cost-benefit analysis and concludes that the different approaches are completely equivalent when consumption paths are optimal.

Greenstone M and Gayer T. Quasi-experimental and experimental approaches to environmental economics. Journal of Environmental Economics and Management. 2009; 57(1).

DOI Link: <http://dx.doi.org/10.1016/j.jeem.2008.02.004>

Paper argues for the use of empirical approaches (quasi-experimental and experimental techniques) in environmental economics over the traditional use of associated evidence as a way to eliminate selection bias and lead to more efficient environmental policies that increase social welfare.

Grosse SD, Teutsch SM, and Haddix AC. Lessons from cost-effectiveness research for United States public health policy. Annual Review of Public Health. 2007; 28(1).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/17222080>

DOI Link: <http://dx.doi.org/10.1146/annurev.publhealth.28.021406.144046>

Paper argues that while economic evaluations have had little impact on public health policy to date, cost-effectiveness analysis is an important tool for decision makers to use in assessing the value of preventive services, programs, and policies. The emergence of methodological standards is improving the quality and consistency of studies.

Hanemann WM. Valuing the environment through contingent valuation. The Journal of Economic Perspectives. 1994; 8(4).

URL: <http://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.8.4.19>

Paper focuses on the use of contingent valuation to measure people's values for environmental resources, rather than specifically on natural resource damages. It describes conducting reliable surveys, addresses common objections to surveys, and considers the compatibility between contingent valuation and economic theory.

Hanley N, Ryan M, and Wright R. Estimating the monetary value of health care: Lessons from environmental economics. Journal of Health Economics. 2003; 12(1).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/12483757>

DOI Link: <http://dx.doi.org/10.1002/hec.763>

Article identifies and summarizes some key issues and debates that surround the field of environmental economics in literature, and considers how health economists have addressed these issues.

Hubbell B. Implementing QALYs in the analysis of air pollution regulations. Environmental and Resource Economics. 2006; 34(3).

DOI Link: <http://www.epa.gov/ttnecas1/workingpapers/ereqaly.pdf>

Paper examines the implications of the quality adjusted life years (QALY) method, and provides an overview of the key issues involved in implementing this approach for evaluating the health impacts of air pollution regulations. These issues are illustrated using an example based on the U.S. Environmental Protection Agency's Heavy Duty Engine/Diesel Fuel regulations.

Kolb JA and Scheraga JD. Discounting the benefits and costs of environmental regulations. Journal of Policy Analysis and Management. 1990; 9(3).

DOI Link: <http://dx.doi.org/10.2307/3325282>

Paper develops a procedure for discounting the benefits and costs of environmental programs, and provides information on the rates that might be used in discounting procedures. It compares the results of the procedure to conventional discounting for representative benefit-cost streams and for selected environmental regulation.

Murphy KM and Topel RH. The value of health and longevity. Journal of Political Economy. 2006; 114(5).

URL: http://www.ucema.edu.ar/u/je49/capital_humano/Murphy_Topel_JPE.pdf

Paper develops an economic framework for valuing improvements to health and life expectancy, based on individuals' willingness to pay, and applies the framework to past and prospective reductions in mortality risks. It concludes that historical gains from increased longevity and potential gains from future health care innovations are both large.

Remoundou K and Koundouri P. Environmental effects on public health: An economic perspective. International Journal of Environmental Research and Public Health. 2009; 6(8).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/19742153>

DOI Link: <http://dx.doi.org/10.3390/ijerph6082160>

Article provides a review of the literature on valuation studies eliciting monetary values associated with reduced environmental risk, in particular focusing on reduced indoor and outdoor air pollution, enhanced water quality and climate change mitigation. The findings of the valuation studies have important policy implications. Minimizing exposure to environmental risk factors by enhancing air quality and access to improved sources of drinking and bathing water, sanitation, and clean energy is found to be associated with significant health benefits and can contribute significantly to the achievement of the Millennium Development Goals of environmental sustainability, health, and development.

Roe B, Boyle KJ, and Teisl MF. Using conjoint analysis to derive estimates of compensating variation. Journal of Environmental Economics and Management. 1996; 31(2).

DOI Link: <http://dx.doi.org/10.1006/jeem.1996.0037>

Paper uses several approaches to derive estimates of Hicksian compensating variation from conjoint ratings data, and finds that conjoint analyses are not a panacea for the problems being debated regarding contingent-valuation and travel-cost methodologies. It concludes that conjoint questions appear to share many of the advantages and disadvantages associated with dichotomous-choice, contingent-valuation questions.

Russell LB, Gold MR, Siegel JE, Daniels N, and Weinstein MC. The role of cost-effectiveness analysis in health and medicine. JAMA: The Journal of the American Medical Association. 1996; 276(14).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/8827972>

Article discusses the development of consensus-based recommendations for cost-effectiveness analysis (CEA) by the Panel on Cost-Effectiveness in Health and Medicine, which define a "reference case" of cost-effectiveness analysis and standard set of methods to serve as a point of comparison across studies. Though CEA does not reflect every element of importance in health care decisions, the information it provides is critical to informing decisions about the allocation of health care resources.

Schmitt LHM. QALY gain and health care resource impacts of air pollution control: A Markov modelling approach. Environmental Science and Policy. 2016; 63.

DOI Link: <http://dx.doi.org/10.1016/j.envsci.2016.05.015>

This paper proposes a new approach to evaluate health and economic benefits of air pollution control in England and Wales. The researchers used a new Markov model to estimate the joint impact of air pollution control measures on the quality and length of individuals' lives over time. They used this method to calculate reductions in quality-adjusted life years (QALYs) for cardio-respiratory effects due to long-term exposure to particulate matter (PM_{2.5}) air pollutants. Reducing PM_{2.5} by 1 µg/m³ results in an increase of 603,000 QALYs in England and Wales for a total discounted monetary benefit of £38 billion.

Smith KR, Corvalán CF, and Kjellström T. How much global ill health is attributable to environmental factors? *Epidemiology*. 1999; 10(5).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/10468437>

Paper attempts to explain why there is large variance in estimations of the portion of human mortality and morbidity attributable to environmental factors, and provides recommendations for deriving such estimates more consistently in the future. Using these recommendations, it estimates that one quarter to one third of global ill health (as of 1999) is attributable to environmental factors.

Treich N. The value of a statistical life under ambiguity aversion. *Journal of Environmental Economics and Management*. 2010; 59(1).

DOI Link: <http://dx.doi.org/10.1016/j.jeem.2009.05.001>

Article argues that most VSL (value of statistical life) estimates do not seem to capture an ambiguity premium, which may result in under-estimates of the VSL applied to ambiguous risks (e.g., environmental risks). In examining the theory of ambiguity aversion, the author shows that existence of ambiguity over baseline mortality risks increases the VSL when the decision maker is averse to ambiguity, and concludes that ambiguity aversion may potentially play an important role in valuation of health and mortality risk changes within cost-benefit analysis.

Urge-Vorsatz D, Herrero ST, Dubash NK and Lecocq F. Measuring the co-benefits of climate change mitigation. *Ann Rev Environ Resources*. 2014; 39.

DOI Link: <http://dx.doi.org/10.1146/annurev-environ-031312-125456>

This article reviews different methodological frameworks that are available to quantify and monetize different co-impacts for decision making related to climate change policy. It also provides methodological guidance on the quantification of these co-impacts and their integration into climate-related decision making based on literature. The review calls for new research and innovation towards simplified evaluation methods and streamlined tools for widely applicable appraisals of co-impacts for decision making.

Category: Health Economics, Methodology, International

Ramos GFP. Cost-effectiveness of primary prevention of paediatric asthma: A decision-analytic model. *European Journal of Health Economics*. 2014; 15(8).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/24096902>

DOI Link: <http://dx.doi.org/10.1007/s10198-013-0532-x>

This study analyzed the cost effectiveness of primary prevention interventions to reduce asthma among Dutch children. The researchers used a decision-analytic tree model to analyze healthcare costs comparing children who received usual care to those who received unifaceted or multifaceted interventions. Costs were evaluated using incremental cost-effectiveness ratios and net monetary benefits. Multifaceted interventions were more costly but more effective in preventing asthma with an incremental cost effectiveness ratio of €8,209.20 per additional asthma case prevented. Interventions that reduced dust mite, pet dander, and second-hand smoke exposure reductions and increased breast-feeding were found to be cost-effective interventions.

Category: Health Economics, Methodology, Not Environment

Russell LB and Sinha A. Strengthening cost-effectiveness analysis for public health policy. American Journal of Preventive Medicine. 2016; 50(5).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27102861>

DOI Link: <http://dx.doi.org/10.1016/j.amepre.2015.11.007>

This review article discusses the evolution and application of cost-effectiveness analysis (CEA) in the context of public health policy. Though typically used in the health sector, the authors discuss using CEA to assess interventions that improve conditions in which Americans live and work (e.g., pollution control, occupational safety, and healthy buildings). They compare the use and outputs of CEA with cost-benefits analysis (CBA). They suggest that policy makers can get valuable but different information from each approach.

Soler R, Orenstein D, Honeycutt A, Bradley C, Trogdon J, Kent CK, Wile K, Haddix A, O'Neil D, Bunnell R, and Communities Putting Prevention to Work Leadership Team. Community-based interventions to decrease obesity and tobacco exposure and reduce health care costs: Outcome estimates from communities putting prevention to work for 2010-2020. Prev Chronic Dis. 2016; 13.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27055264>

DOI Link: <http://dx.doi.org/10.5888/pcd13.150272>

This study calculated short-term and long-term benefits of the Centers for Disease Control and Prevention (CDC) communities Putting Prevention to Work (PPW) program to reduce obesity, tobacco use, and exposure to second hand smoke. They calculated the numbers of premature deaths, health care costs, and productivity losses that were avoided as a result of the PPW program. They used the Prevention Impacts Simulation Model (PRISM), which is a systems dynamics model of cardiovascular disease prevention. They calculated that the \$485 million program prevented \$2.4 billion in direct medical costs and \$9.5 billion in productivity losses between 2010 and 2020. The greatest impact came from programs that fostered increased physical activities and implemented advertising against smoking.

Squires H, Chilcott J, Akehurst R, Burr J, and Kelly MP. A framework for developing the structure of public health economic models. Value in Health. 2016; 19(5).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27565276>

DOI Link: <http://dx.doi.org/10.1016/j.jval.2016.02.011>

This article presents the first formal conceptual modeling framework for public health economic evaluation. Modeling public health interventions is challenging because of the range of factors that have to be considered in addition to the clinical factors. Based on previous literature and further analysis, key principles of good practice and a methodology were developed. Using the framework, the quality and validity of public health economic models and analyses could be improved.

Thompson KM and Tebbens RJ. Retrospective cost-effectiveness analyses for polio vaccination in the United States. Risk Analysis. 2006; 26(6).

URL: <http://www.ncbi.nlm.nih.gov/pubmed/17184390>

Study presents a retrospective cost-effectiveness analysis of polio vaccinations in the United States, determining that historical and future investments translate into over 1.7 billion vaccinations that prevent approximately 1.1 million cases of paralytic polio and over 160,000 deaths, with a net benefit of approximately \$180 billion US dollars. These retrospective findings suggest that the US investment in polio vaccination represents a highly valuable, cost-saving public health program.

Category: International

Abe KC and Miraglia SG. Health impact assessment of airpollution in Sao Paulo, Brazil. Int J Environ Res Public Health. 2016; 13(7).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27409629>

DOI Link: <http://dx.doi.org/10.3390/ijerph13070694>

The researchers present calculations of health gains and associated cost savings that would result from lowering the Brazilian air standards for PM2.5 and PM10. They used the World Health Organization Health Impact Assessment method approach and data from 2009-2011 to evaluate the potential health effects of a change in air pollution standards. If Brazil adopted the WHO standards of 10 µg/m³ for PM2.5, Sao Paulo would avoid 5,012 deaths (266,486 life years gained) and save US\$15.1 billion each year. Sao Paolo had daily mean concentrations of 21 µg/m³ of PM2.5, and 36 µg/m³ of PM10. The authors urge adoption of the WHO standards in Brazil.

Andersen ZJ, Sram RJ, Scasny M, Gurzau ES, Fucic A, Gribaldo L, Jr. Rossner P, Rossnerova A, Kohlova MB, Maca V, Zverinova I, Gajdosova D, Moshhammer H, Rudnai P, and Knudsen LE. Newborns health in the Danube Region: Environment, biomonitoring, interventions and economic benefits in a large prospective birth cohort study. Environ Int. 2016; 88.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26735349>

DOI Link: <http://dx.doi.org/10.1016/j.envint.2015.12.009>

This article proposes the concept of formation of a new multi-center epidemiological cohort in the Danube Region, which consists of 14 countries with more than 100 million people. Many heavily polluted areas are located in this region. The project will characterize in utero exposures to multiple environmental factors using biomarkers, and measure growth, respiratory, allergic, immunologic, and neurodevelopmental health as the children grow. Economic measures include parents' willingness to pay for health risk reductions, and cost-of-illness values.

Archer-Nicholls S, Carter E, Kumar R, Xiao Q, Liu Y, Frostad J, Forouzanfar MH, Cohen A, Brauer M, Baumgartner J, and Wiedinmyer C. The regional impacts of cooking and heating emissions on ambient air quality and disease burden in China. Environ Sci Technol. 2016; 50(17).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27479733>

DOI Link: <http://dx.doi.org/10.1021/acs.est.6b02533>

This article reports that, of all premature deaths in China that are due to particulate matter (PM2.5) air pollution, 37 percent are attributable to home heating and cooking emissions. The researchers used a regional modeling sensitivity analysis of residential emissions at the provincial level. Using Global Burden of Disease 2013 framework spatially resolved health and population data, they calculated the proportion of deaths and disability adjusted life years attributed to residential PM2.5 exposure. The authors concluded that 341,000 premature deaths annually in China are attributable to residential combustion emissions. Importantly, they found that both cooking and heating activities contributed to exposures so exposure reduction strategies should address both sources.

Asikainen A, Carrer P, Kephelopoulos S, Fernandes ED, Wargocki P, and Hanninen O. Reducing burden of disease from residential indoor air exposures in Europe (HEALTHVENT project). Environmental Health. 2016; 15.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26961383>

DOI Link: <http://dx.doi.org/10.1186/s12940-016-0101-8>

This study determined that, in Europe, setting policies to control indoor sources and optimize ventilation rates for indoor air pollutants would provide larger health benefits than filtering outdoor air.

Researchers estimated the burden of disease for asthma, cardiovascular diseases, and other respiratory diseases attributable to air pollution. They calculated an annual loss of 2.1 million disability adjusted life years (DALYs) attributed to air pollutants, and 0.74 million of those were attributed to indoor air. The researchers identified particulate matter (PM2.5) as the cause of the majority of health effects.

Exposure control scenarios estimated 20–44 percent reductions in the burden of disease for each of three exposure control approaches analyzed, and indoor source control and ventilation provided the largest risk reductions.

Ciucci A, D'elia I, Wagner F, Sander R, Ciancarella L, Zanini G, and Schopp W. Cost-effective reductions of PM2.5 concentrations and exposure in Italy. Atmospheric Environment. 2016; 140.

DOI Link: <http://dx.doi.org/10.1016/j.atmosenv.2016.05.049>

This study applied the multi-pollutant, multi-effect GAINS (Greenhouse Gas Air Pollution Interactions and Synergies) model in Italy on a regional basis in the context of setting target levels for PM2.5 air pollution. They compared three policy scenarios for setting cost-effective National Emission Ceilings and specific control measures to set targets for PM2.5 pollution in 2020. They found that a regional health impact-oriented approach that utilized Years of Life Lost (YOLL) is more cost-effective than a nation-wide limit on ambient air quality.

Conrad K and Morrison CJ. The impact of pollution abatement investment on productivity change: an empirical comparison of the US, Germany, and Canada. Southern Economic Journal. 1989; 55(3).

DOI Link: <http://dx.doi.org/10.2307/1059582>

This study explored whether environmental regulations of the early 1970s contributed to productivity slow-downs in the U.S., Canada, and Germany. The researchers developed a theoretical model of the decisions of a company facing pollution emission standards that recognizes effects of the standards and resulting capital investments. They reported that some approaches to spending pollution abatement capital can contribute to downward trends in productivity.

Devos S, Cox B, Van Lier T, Nawrot TS, and Putman K. Effect of the shape of the exposure-response function on estimated hospital costs in a study on non-elective pneumonia hospitalizations related to particulate matter. Environment International. 2016; 94

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27342649>

DOI Link: <http://dx.doi.org/10.1016/j.envint.2016.06.012>

This study evaluated associations between particulate matter air pollution (PM2.5) and hospital pneumonia admissions in Belgium. The researchers calculated the annual averted pneumonia hospitalization costs if the Belgian air pollution standard were lowered to 10 µg/m³, the current World Health Organization standard. They calculated a risk reduction of 4.9%, and annual hospital cost saving of €15-34 million, depending on whether log-linear or log-log E-R functions were used. These results suggest that there may be significant health benefits if air regulations were revised.

Du Y and Li T. Assessment of health-based economic costs linked to fine particulate (PM2.5) pollution: A case study of haze during January 2013 in Beijing, China. *Air Quality, Atmosphere and Health*. 2016; 9(4).

DOI Link: <http://dx.doi.org/10.1007/s11869-015-0387-7>

This study calculated economic costs of high levels of exposure to fine particulate matter (PM2.5) air pollution in China during January 2013. During this month, Beijing PM2.5 concentrations were 4 to 9 times higher than levels recommended by the World Health Organization. The economic cost of 479 acute deaths from all causes that were attributable to the extreme haze was ~USD\$180 million, or 0.76% of the GDP. At the district level, generally higher pollution levels and higher population density led to higher economic costs.

Gaskin J, Rennie C, and Coyle D. Reducing periconceptional methylmercury exposure: Cost-utility analysis for a proposed screening program for women planning a pregnancy in Ontario, Canada. *Environmental Health Perspectives*. 2015; 123(12).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26024213>

DOI Link: <http://dx.doi.org/10.1289/ehp.1409034>

This study calculated the cost effectiveness of screening blood mercury (Hg) concentrations in women planning to become pregnant in Ontario, Canada order to provide fish intake recommendations and reduce exposure of fetuses to Hg. The outcomes measured were loss in the quality of life and remedial education costs due to neurological deficits over the lifetime associated with Hg exposure during pregnancy. The incremental cost per quality-adjusted life year (QALY) gained for the proposed screening intervention was estimated to be \$18,051 (CAD) and the expected value for a willingness to pay of \$50,000(CAD)/QALY to be \$0.61(CAD). The authors concluded that the screening program would be highly cost-effective.

Greenstone M and Hanna R. Environmental regulations, air and water pollution, and infant mortality in India. *The American Economic Review*. 2014; 104(10).

URL: <https://www.aeaweb.org/articles?id=10.1257/aer.104.10.3038>

DOI Link: https://www.theigc.org/wp-content/uploads/2016/06/Greenstone_Hanna.pdf

This study analyzed the effectiveness of two pollution reduction policies in India by using city-level air and water pollution data and infant mortality data to calculate benefits of the regulations. Air regulations contributed to improved air quality and a slight reduction in infant mortality (results were not statistically significant). The water regulations failed to improve water conditions. The authors suggest that citizens' demand for improved air quality prompted the Indian Supreme Court to take action and contributed to the successes.

Hanna R and Oliva P. The effect of pollution on labor supply: Evidence from a natural experiment in Mexico City. *Journal of Public Economics*. 2015; 122.

DOI Link: <http://dx.doi.org/10.1016/j.jpubeco.2014.10.004>

This article presents evidence that reductions in air pollution contribute to increases in labor supply related to increased numbers of work days. The researchers studied a population of 890,000 people in Mexico City near a large oil refinery before and after closure of the refinery. They found that closure resulted in a 20 percent reduction in sulfur dioxide (SO₂) air concentrations and a 3.5 percent increase in number of hours worked per week. The increase was not due to changes in number of workers in the community. The closure was thus associated with a gain of about \$112 million USD in increased labor supply during the first year after closure. The authors argue that these benefits should be included when assessing the overall benefits of closure of the plant.

Hou Q, An X, Tao Y, and Sun Z. Assessment of resident's exposure level and health economic costs of PM10 in Beijing from 2008 to 2012. Sci Total Environ. 2016; 563-564.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27155078>

DOI Link: <http://dx.doi.org/10.1016/j.scitotenv.2016.03.215>

This paper reports that economic costs associated with particulate matter (PM10) air pollution in different districts and counties in Beijing, China, increased between 2008 and 2012. The researchers used high resolution GIS mapping of PM10 air concentrations and population numbers. They also determined exposure-response relationships of PM10 levels with eight health endpoints (e.g., mortality, chronic bronchitis, asthma, and hospital admission rate for respiratory diseases). The average economic cost over 5 years was USD\$4.5 billion in the city area, and USD\$4.95 billion in the suburban area.

Kowalski, M, Kowalska K, and Kowalska M. Health benefits related to the reduction of PM concentration in ambient air, Silesian Voivodeship, Poland. Int J Occup Med Environ Health. 2016; 29(2).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26670352>

DOI Link: <http://dx.doi.org/10.13075/ijomeh.1896.00493>

This study used Health Impact Assessment (HIA) tools developed by the World Health Organization to calculate health benefits of reduced exposure to particulate matter (PM10 and PM2.5) air pollution in the context of possibly changing regulatory air pollution standards in Poland. Researchers primarily focused on total mortality and cardio-respiratory hospitalization rates in the Silesian region. They calculated that reducing long-term exposure to PM2.5 by 5 µg/m³ would result in an additional 4.8 months of life per capita for people 30 years old and older, and an additional 10.8 months in Zabrze city. They also calculated that 62.8 hospitalizations for respiratory and cardiac disease could have been avoided if PM10 levels were lowered to 20 µg/m³. Measured PM10 concentrations in Zabrze city was 61 µg/m³.

Kumar A, Gupta I, Brandt J, Kumar R, Dikshit AK, and Patil RS. Air quality mapping using GIS and economic evaluation of health impact for Mumbai City, India. J Air Waste Manag Assoc. 2016; 66(5).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26828812>

DOI Link: <http://dx.doi.org/10.1080/10962247.2016.1143887>

This study analyzed the relationships between air quality and health impact costs in Mumbai by using GIS and modeling to obtain detailed air monitoring data from existing air monitoring stations. Results for sulfur dioxide, nitrogen dioxide, and suspended particulate matter were studied using three different spatial mapping techniques. Using these data, the researchers calculated that the total health cost for Mumbai city in 2012 was approximately US\$8 billion. The results also show that air quality measures can be interpolated when air monitoring stations are not available.

Lu XC, Yao T, Fung JCH, and Lin CQ. Estimation of health and economic costs of air pollution over the Pearl River Delta region in China. Science of the Total Environment. 2016; 566.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27220091>

DOI Link: <http://dx.doi.org/10.1016/j.scitotenv.2016.05.060>

This study estimated economic losses from SO₂, NO₂, ozone, and particulate matter (PM10) air pollutant exposures in the Pearl River Delta region of China from 2010 to 2013. Short-term all-cause deaths attributed to these air pollutants were highest in 2013 with 13,217-22,800 attributable deaths in the region. NO₂ was associated with the most cases of death and disease. Economic losses in 2013 attributed to the air pollutants were USD\$14,768–\$23,305 million, representing 1.4–2.3 percent of the regional gross domestic product.

Mahanta R, Chowdhury J, and Nath HK. Health costs of arsenic contamination of drinking water in Assam, India. *Economic Analysis and Policy*. 2016; 49.

DOI Link: <http://dx.doi.org/10.1016/j.eap.2015.11.013>

This study calculated the annual health costs and welfare gains associated with arsenic contamination of drinking water in Assam, India. For every 1 microgram increase of arsenic concentration, there is an estimated annual health cost of INR 0.76 million (USD 0.01 million) using the three stage least square estimation procedure. Health costs include sick day wage losses and medical expenditures. If the concentration was brought down to the safe limit of 50 micrograms per liter, estimated welfare gains would be INR 153 million (USD 2.49 million).

Miranda AI, Ferreira J, Silveira C, Relvas H, Duque L, Roebeling P, Lopes M, Costa S, Monteiro A, Gama C, Sa E, Borrego C, and Teixeira JP. A cost-efficiency and health benefit approach to improve urban air quality. *Science of the Total Environment*. 2016; 569.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27348699>

DOI Link: <http://dx.doi.org/10.1016/j.scitotenv.2016.06.102>

This study analyzed implementation costs and associated health impact economic costs for four different abatement approaches to reduce particulate matter (PM10) and nitrogen oxide (NOx) air pollutants in Portugal. The researchers used the “Moving from Air Pollution to Local Integrated Assessment” (MAPLIA) system to analyze 15 emission scenarios that were simulated using the TAPM air quality modeling tool. The scenario in which open fire places were replaced with heat recovery wood stoves yielded the largest net benefit. Although the most expensive scenario, the benefits outweighed the costs. The authors concluded that the MAPLIA system is a useful tool to support policy decision making.

Sayal A, Amjad S, Bilal M, Pervez A, Mahmood Q, and Afridi MA. Industrial water contamination and health impacts: An economic perspective. *Polish Journal of Environmental Studies*. 2016; 25(2).

DOI Link: <http://dx.doi.org/10.15244/pjoes/60724>

This study measured health impacts and costs of exposure to lead (Pb) in drinking water in Dingi village in Pakistan. The village (population 5,021) is located downstream of a wastewater channel carrying untreated industrial waste. Researchers used a probit model to estimate medical expenses and exposure prevention costs incurred by households due to Pb exposures as well as other medical and health costs. The total welfare loss to households exposed to Pb contamination was 4.26 million PKR (\$42,000 USD). Thus families were spending 5% of their annual income on Pb-associated illness, which the authors characterize as a substantial burden in this poor community.

Simons K, Devos S, Putman K, Coomans D, Van Nieuwenhuysse A, and Buyl R. Direct cost saving potential in medication costs due to a reduction in outdoor air pollution for the Brussels Capital Region. *Science of the Total Environment*. 2016; 562.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27110987>

DOI Link: <http://dx.doi.org/10.1016/j.scitotenv.2016.04.022>

This study estimated annual cost savings in medication purchases for a 10% reduction in NO₂ and particulate matter (PM₁₀ and PM_{2.5}) air pollutants in the Brussels Capital Region in Belgium. The researchers used a time series analysis approach to model daily sales of asthma and chronic obstructive pulmonary disease medicines with daily NO₂ air pollution levels. There was a significant association between the prescription medication purchases and NO₂ levels but not PM levels. With a 10 percent reduction in NO₂ levels, annual cost savings would be €108 thousand for a city with 1 million inhabitants, extrapolated to €1.2 million nationwide.

Sun C, Kahn ME, and Zheng S. Self-protection investment exacerbates air pollution exposure inequality in urban China. *Ecological Economics*. 2017; 131.

DOI Link: <http://dx.doi.org/10.1016/j.ecolecon.2016.06.030>

This study demonstrates that income disparities contributed to pollution exposure disparities in China based on purchases of self-protection equipment to reduce air pollution exposures. City-level data showed that purchases of equipment increased with government announcements of increased pollutant levels. Richer people were more likely to purchase more expensive and more effective devices (e.g., portable room air filters). Higher housing prices in less-polluted areas and greater use of personal cars (instead of walking outside) also contribute to disparities in personal exposures based on income.

Trasande L, Zoeller RT, Hass U, Kortenkamp A, Grandjean P, Myers JP, Digangi J, Hunt PM, Rudel R, Sathyanarayana S, Bellanger M, Hauser R, Legler J, Skakkebaek NE, and Heindel, JJ. Burden of disease and costs of exposure to endocrine disrupting chemicals in the European Union: an updated analysis. *Andrology*. 2016; 4(4).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27003928>

DOI Link: <http://dx.doi.org/10.1111/andr.12178>

This study reports updated calculations of a range of health and economic costs attributed to endocrine disrupting chemicals (EDCs) in the European Union (EU) based on new information from expert panels and published research. Expert panels identified at least 11 health endpoints with probable causation by EDCs (e.g., IQ loss, autism, endometriosis, and adult diabetes). Monte Carlo simulations produced a median annual cost of €163 billion (1.28% of EU Gross Domestic Product). The authors concluded that EDCs contribute substantially to the burden of disease and costs in the EU.

Wang G, Gu S, Chen J, Wu X, and Yu J. Assessment of health and economic effects by PM2.5 pollution in Beijing: A combined exposure-response and computable general equilibrium analysis. *Environ Technol*. 2016; 37(24).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/27143216>

DOI Link: <http://dx.doi.org/10.1080/09593330.2016.1178332>

This study estimated health effects, health costs, and gross domestic product (GDP) loss due to health impacts of particulate matter (PM2.5) air pollution in Beijing, China in 2013. The researchers used a new modification of the computable general equilibrium model to assess impacts on sector- and city-wide economic systems. They estimated that 20,403 premature deaths and one million other medical cases were attributed to PM2.5 pollution. The resulting GDP losses were estimated to be 1286.97 million RMB, which is a huge loss according to the authors.

Wang K, Wu J, Wang R, Yang Y, Chen R, Maddock JE, and Lu Y. Analysis of residents' willingness to pay to reduce air pollution to improve children's health in community and hospital settings in Shanghai, China. *Sci Total Environ*. 2015; 533.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26172595>

DOI Link: <http://dx.doi.org/10.1016/j.scitotenv.2015.06.140>

This study used the Contingent Valuation Method (CVM) to measure willingness to pay for reducing children's respiratory disease in Shanghai, China. Parents in community and hospital settings were interviewed. Parents in the hospital setting were willing to pay significantly more (¥504, or USD\$80.7) than parents in the community sample (¥428, or USD\$68.5)). Important predictors were education and income. The authors noted that the hospital setting may provide a unique opportunity to improve education about air quality and children's health as the parents may be more receptive to the information.

Xia Y, Guan D, Jiang X, Peng L, Schroeder H, and Zhang Q. Assessment of socioeconomic costs to China's air pollution. Atmospheric Environment. 2016; 139.

DOI Link: <http://dx.doi.org/10.1016/j.atmosenv.2016.05.036>

This paper utilized estimate economic costs of total output losses resulting from reduced labor availability caused by diseases related to particulate matter (PM2.5) air pollution across 30 Chinese provinces in 2007. The researchers used a supply-driven input-output (I-O) model to calculate direct and indirect losses. They calculated that 72 million workers were affected out of a total labor population of 712 million. Total economic losses were 346.26 billion Yuan (approximately 1.1% of the national GDP). The study is the first in integrating risk, impact, and inter-dependency analyses into health cost assessment.

Yang S and He L-Y. Fuel demand, road transport pollution emissions and residents' health losses in the transitional China. Transportation Research: Part D: Transport and Environment. 2016; 42.

DOI Link: <http://dx.doi.org/10.1016/j.trd.2015.10.019>

This study analyzed links between fuel prices, air pollution, and residents' health losses in several regions in China. The authors used models to derive air pollution levels from fuel costs and usage levels. Then they derived exposure-response estimates based on epidemiological studies for several health outcomes. They found that lower prices led to increased fuel consumption and increased health losses from the resulting higher levels of pollution.

Yao T, Sung HY, Mao Z, Hu TW, and Max W. The healthcare costs of secondhand smoke exposure in rural China. Tob Control. 2015; 24(e3).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/25335898>

DOI Link: <http://dx.doi.org/10.1136/tobaccocontrol-2014-051621>

This study calculated healthcare costs attributed to adult second hand smoke (SHS) exposure in rural China. The researchers used national survey results to calculate SHS-related healthcare costs for asthma, breast cancer (in females), heart disease, lung cancer, and tuberculosis. Total costs were \$1.2 billion in 2011, with a large proportion attributed to women (\$877.1 million). Out-of-pocket expenditure per person was 47 percent of their daily income. The authors concluded that reducing SHS exposure could have a substantial economic impact in poor, rural areas of China.

Zhao X, Yu X, Wang Y, and Fan C. Economic evaluation of health losses from air pollution in Beijing, China. Environ Sci Pollut Res Int. 2016; 23(12).

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26944425>

DOI Link: <http://dx.doi.org/10.1007/s11356-016-6270-8>

This study estimated economic losses that were attributed to particulate matter (PM10) air pollution in Beijing, China, based on field collection data in 2012 and health impact data from a Hong Kong study. The health losses were estimated to be ¥583.02 million or 0.03 % of China's gross domestic product (GDP). Premature deaths were the leading cause of human health losses. Older people had more premature deaths, and younger people suffered the highest per capita economic losses. The total economic losses includes medical costs and human depreciation costs of cardiovascular and respiratory diseases.

Zheng S, Sun C, Qi Y and Kahn ME. The evolving geography of China's industrial production: implications for pollution dynamics and urban quality of life. Journal of Economic Surveys. 2014; 28(4).

URL: <http://www.nber.org/papers/w19624>

DOI Link: <http://dx.doi.org/10.1111/joes.12063>

This review article describes the new economic geography of China, as rapid economic growth has shifted industrialization from the coastal eastern cities to inland cities, and the pollution and negative quality of life impacts that have gone with it. There is evidence that the new inland factories are choosing greener technologies that will lead to less pollution. The environmental regulations are stricter in rich coastal cities than in more lax inland cities, where the local government is concerned about attracting economic growth and jobs. Future research should consider constructing a general equilibrium model in which industrial production creates wealth and pollution, and then assess how a strategic national government could encourage growth and improved quality of life.

Zhu J, Liu JG, Hu JX, and Yi S. Socio-economic analysis of the risk management of hexabromocyclododecane (HBCD) in China in the context of the Stockholm Convention. Chemosphere. 2016; 150.

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26615892>

DOI Link: <http://dx.doi.org/10.1016/j.chemosphere.2015.11.007>

This article presents the first holistic and quantitative Socio-economic Analysis (SEA) case study on risk management of chemicals in China focusing on hexabromocyclododecane (HBCD). The authors demonstrated that phasing out HBCD over 5 years would be more costly but more beneficial to the environment and human health compared to a phase out over 10 years. The SEA framework and methodology in this paper is specific to China as a developing country. Costs of construction, waste management, numbers of workers at risk, and monetized health benefits are examples of quantitative assessments used in the analysis.

Zvingilaite E and Klinge Jacobsen H. Heat savings and heat generation technologies: Modelling of residential investment behaviour with local health costs. Energy Policy. 2015; 77.

DOI Link: <http://dx.doi.org/10.1016/j.enpol.2014.11.032>

This study analyzed the impact of health costs for Denmark households on their decision to invest in heat-saving approaches (e.g., install insulated windows), or a secondary heating source for their home (e.g., a wood stove). Their model incorporated health-related costs of particle air pollution from wood stoves. Heat-saving approaches had lower health costs and more socioeconomic value than heat-adding approaches, but people were more inclined to use heat-adding approaches. The authors suggested changes in the Danish tax structure or other policy-based incentives to encourage investments in heat-saving approaches.

Gray Literature: Working Papers and Reports

Boesch HJ, Kahlmeier S, Sommer H, van Kempen E, Staatsen B, and Racioppi F. Economic valuation of transport-related health effects: Review of methods and development of practical approaches, with a special focus on children. 2008.

Organization: WHO Regional Office for Europe

URL: <http://apps.who.int/iris/bitstream/10665/107923/1/E92127.pdf>

Report develops practical approaches to the economic valuation of transport-related health effects, including a focus on children. It is targeted at non-health experts and practitioners in transport planning.

Carlin A. EPA's environmental investments: The cost of a clean environment.

URL: [http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0294A-1.pdf/\\$file/EE-0294A-1.pdf](http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0294A-1.pdf/$file/EE-0294A-1.pdf)

Executive report discusses and summarizes the economic costs (e.g., air, radiation, water, and land) and approaches related to environmental protection and pollution control.

Chang T, Zivin JG, Gross T, and Neidell M. The effect of pollution on worker productivity: Evidence from call-center workers in China. NBER Working Paper Series. 2016; w22328.

URL: <http://www.nber.org/papers/w22328>

This paper reports that higher daily levels of air pollution was associated with reduced daily productivity for indoor, white-collar workers. At two call centers in China, a 10-unit increase in the air pollution index decreased the number of daily calls handled by each worker by an average of 0.35 percent. The effects were noted at levels that are commonly found in cities around the world. The reduced productivity was due to more time spent on breaks. The authors estimated that a modest decrease in air pollution in China could increase productivity by billions of dollars per year. The authors also discuss how particulate matter exposure can impact labor productivity.

Chen Z, Kahn ME, Liu Y and Wang Z. The consequences of spatially differentiated water pollution regulation in China. NBER Working Paper Series. 2016; w22507.

URL: <http://www.nber.org/papers/w22507>

This study analyzed the local impact and unintended consequences of environmental regulation on water pollution in areas near the Yangtze River in China. The river supplies drinking water for 4 million people, and will go up to 800 million after infrastructure changes are implemented. The authors reported that differential local regulations shifted water pollution from downstream locations to upstream locations that had fewer regulations. Upstream pollution also affects downstream locations, so the number of people affected increased.

Clay K, Lewis J, and Severnini E. Pollution, infectious disease, and mortality: Evidence from the 1918 Spanish influenza pandemic. NBER Working Paper Series. 2015; w21635.

DOI Link: <http://dx.doi.org/10.3386/w21635>

This study assessed whether air pollution increased susceptibility to Spanish influenza during the 1918 pandemic in the US. The short-lived and severe outbreak killed an estimated 675,000 Americans. As an estimate of air pollution, the total coal-fired electricity capacity within 30 miles was used as a measure of bituminous coal consumption. Coal consumption was associated with a 25-40 percent increase in infant mortality, and a 10-14 percent increase in all-age mortality during the pandemic. They developed a simple model of city-health capital to discern effects of pre-pandemic pollution exposure and concurrent pollution exposure on susceptibility.

Clay K, Lewis J, and Severnini E. Canary in a coal mine: Infant mortality, property values, and tradeoffs associated with mid-20th century air pollution. NBER Working Paper / IZA Discussion Paper. 2016; w22155.

URL: <http://www.nber.org/papers/w22155>

This study analyzed the costs and benefits of the expanded use of coal-fired electricity generation during the mid-20th century expansion of the US power grid. During 1938-1962, emissions were virtually unregulated. By 1962, coal combustion pollution was responsible for 3,500 infant deaths per year (1 per thousand live births). Counties with low access to electricity showed reduced infant mortality and increased property values, while counties with greater access showed the opposite. The analysis also calculated costs per infant life of 1) moving heavily polluting coal-fired plants to low population-density areas, and 2) implementing pollution abatement. Both calculations were well below the estimated \$1 million (1990 USD) value of statistical life during this period.

Department of Performance Monitoring and Evaluation (DPME). DPME evaluation guideline No 2.2.15 guideline on evaluation synthesis. 2014.

Organization: The Presidency Republic of South Africa

URL:

<http://evaluations.dpme.gov.za/images/gallery/GL%20%20%2015%20Evaluation%20Synthesis%20accepted%2014%2003%2020.pdf>

Guideline is designed to assist government departments to effectively plan and manage economic evaluations. It covers the definition and description of an economic evaluation, key questions economic evaluations can answer, different forms of economic evaluation (e.g., cost-effectiveness analysis, cost-benefit analysis, and cost-utility analysis), common methods and approaches, and key issues to be considered in managing economic evaluations.

Department of Performance Monitoring and Evaluation (DPME). DPME evaluation guideline No 2.2.13 guideline on impact evaluation. 2014.

Organization: The Presidency Republic of South Africa

Guideline provides a definition and description of impact evaluations, which seek to understand the changes brought about by an intervention at an outcome and impact level. It includes key questions impact evaluations can answer, guidance on key forms of impact evaluation and its common methods and approaches, key issues to be considered, and how to manage an impact evaluation.

Families USA Foundation. In your own backyard: How NIH funding helps your State's Economy. 2008.

URL: http://familiesusa.org/sites/default/files/product_documents/in-your-own-backyard.pdf

Report summarizes the economic benefits of NIH funding in the United States, which includes grants to states, business activity, jobs, and wages. NIH-funded research has not only contributed to increases in longevity that have added to national wealth, but it has also resulted in health care cost savings by lowering both the direct costs (hospital and nursing home stays, surgery, and other treatments) and indirect costs (reduced productivity from illness and death) of illness in the United States and globally.

Grether J-M and De Melo J. Globalization and dirty industries: Do pollution havens matter? NBER Working Paper Series. 2003; w9776.

URL: <http://www.nber.org/papers/w9776>

DOI Link: <http://dx.doi.org/10.3386/w9776>

This paper analyzed impacts of globalization on the environment to explore whether increased global trade contributes to increased environmental pollution and resource depletion. The analysis focuses on patterns of trade for heavily polluting manufacturing industries to determine whether globalization allows industries to move to locations with less stringent regulations (“pollution havens” effect) or globalization leads to worldwide degradation of environmental standards. Their evidence supported the pollution havens effect, but there was less movement than they expected. In part, this result was due to relatively high natural barriers to trade in the heavy polluting industries.

Hanlon WW. Pollution and mortality in the 19th century. California Center for Population Research On-Line Working Paper Series / NBER Working Paper No. 21647. 2015; w21647.

URL: <http://www.nber.org/papers/w21647>

This study assessed impacts of pollution on health during the 19th century in Britain. The researcher combined county-level data on the types of industries in local areas with information about the intensity of pollutant output by industry. He concluded that industrial pollution and growing industrial coal use in the late 1800s were major causes of mortality. The estimated value of the loss of life was equal to at least 0.33-1.00 of the annual GDP in 1900.

Herrnstadt E and Muehlegger E. Air pollution and criminal activity: evidence from Chicago microdata. NBER Working Paper Series. 2015; w21787

URL: <http://www.nber.org/papers/w21787>

This working paper estimated the casual effect of air pollution from major interstates on violent criminal behavior in Chicago, Illinois, and the costs of this pollution-induced crime for Chicago and the U.S. The researchers estimated that the downwind side of major interstates in Chicago experienced 2.2 percent more violent crimes than when the wind is blowing the opposite direction. They conservatively estimated the cost of air pollution-induced crime in the U.S. to be \$100-200 million annually. These findings suggest that traditional estimates of the external costs imposed by local air pollution may be understated.

Hofstetter P and Hammitt JK; National Risk Management Research Laboratory, U.S. Environmental Protection Agency (EPA). Human health metrics for environmental decision support tools: Lessons from health economics and decision analysis. 2001.

URL: <http://nepis.epa.gov/Adobe/PDF/900G0U00.pdf>

Report provides a review of the literature on medical decision making and health economics, with special attention to aspects relevant in the environmental context. It summarizes the use of three human health metrics (quality adjusted life years [QALYs], disability adjusted life years [DALYs], and willingness-to-pay [WTP]) that have been used to compare a wide range of different environmental risk factors, and includes recommendations for use of human health metrics in different environmental decision support tools.

Hutton G, Rehfuess E, Tediosi F, and Weiss S. Evaluation of the costs and benefits of household energy and health interventions at global and regional levels. 2006.

Organization: World Health Organization (WHO)

URL: http://apps.who.int/iris/bitstream/10665/43568/1/9789241594790_eng.pdf?ua=1

Publication outlines the methods and data sources that form the basis for cost-benefit analysis of household energy and health interventions (indoor air pollution and cookstoves), and presents the results for eight intervention scenarios of relevance to energy policy in the context of the Millennium Development Goals.

Institute of Medicine (IOM). Costs of environment-related health effects: A plan for continuing study. 1981.

Organization: Institute of Medicine (IOM)

URL: http://www.nap.edu/openbook.php?record_id=812&page=1

Report presents a plan for a congressionally mandated study of costs of environment-related health effects, and includes a framework that would improve the data and methodologies available to relate environmental hazards to health problems and their associated costs. Report also outlines the environmentally attributable fraction (EAF) method, one of the recommended methodologies for quantifying costs related to environmental factors.

Li D. Toxic spring: The capriciousness of cost-benefit analysis under FIFRA's pesticide registration process and its effect on farmworkers. California Law Review. 2015; 103 (5).

URL: <http://www.californialawreview.org/wp-content/uploads/2015/10/06-Li.pdf>

This paper suggests that the US EPA consider modifying their approach to weighing potential harms to public health using cost-benefit analysis when making licensing decisions for pesticides. Using recent litigation over the pesticide Azinphos-methyl as an example, the author argues that the current approach does not adequately consider risks to farmworkers applying chemicals in the field, and favored the growers' financial benefits. She proposed that EPA adopt a system that is more closely aligned with California's regulatory scheme, which limits consideration of benefits. Also, the European REACH approach, which incentivizes the substitution of alternatives to toxic pesticides, should be considered by EPA.

Pitt MM, Rosenzweig MR, and Hassan N. Identifying the cost of a public health success: Arsenic well water Contamination and productivity in Bangladesh. NBER Working Paper Series. 2015; w21741.

URL: <http://www.nber.org/papers/w21741>

This paper reports that arsenic exposure was associated with lower cognitive ability in younger adults (particularly men) but not older adults in a Bangladeshi population that has been studied for 26 years. Younger adults with higher exposure levels were also less likely to have a skilled occupation or to become entrepreneurs. The calculated benefits of reducing exposure included a rise in earnings of \$54 per male worker per year, and an additional increase of \$27 per year of increased productivity for women. The researchers suggested that efforts to provide cleaner water sources may be economically beneficial.

Scasny M and Maca V. Monetary valuation of health risks of heavy metals: state-of-the art and some gaps. 2013.

URL: http://www.e3s-conferences.org/articles/e3sconf/pdf/2013/01/e3sconf_ichm13_22002.pdf

This conference proceedings paper reviews the valuation of health impacts related to heavy metals, and provides an overview valuation of health outcomes in five broad impact categories — carcinogenicity, dose toxicity, sensitization, effects on fertility, and developmental toxicity. It examines and discusses difficulties in translating risk assessment and toxicological research findings of human health effects related to heavy metal exposure to changes in welfare for the general population, as well as gaps in establishing these links in the context of a study commissioned by European Chemicals Agency.

Shubat P and Lockheart A. Report on environmental health economics survey. 2006.

Organization: Minnesota Department of Health, Health Risk Assessment Unit

URL: <http://www.health.state.mn.us/divs/eh/children/economicsrpt.pdf>

Report summarizes preliminary results of a survey administered by the Minnesota Department of Health. The survey was used to learn the advantages and disadvantages of using economics in environmental health in decision-making, specifically exploring the use of economics in gauging public concerns about protecting children from environmental threats, and indicated that adults were more willing to spend money to reduce risks to all children than to reduce risks to all adults. The survey was also used as an opportunity to evaluate and support risk assessment decision-making for specific risk-reduction benefits such as air and water pollutant regulations.

US EPA. The benefits and costs of the Clean Air Act from 1990 to 2020. 2011.

Organization: US EPA Office of Air and Radiation

URL: <https://www.epa.gov/sites/production/files/2015-07/documents/summaryreport.pdf>

Summary report evaluates the benefits and costs of programs implemented between 1990 and 2020 pursuant to the 1990 Clean Air Act Amendments, and finds that the benefits of the amendments far outweigh the costs.

US EPA. Guidelines for preparing economic analyses. 2014.

Organization: US EPA

URL: [http://yosemite.epa.gov/ee/epa/erm.nsf/vwAN/EE-0568-50.pdf/\\$file/EE-0568-50.pdf](http://yosemite.epa.gov/ee/epa/erm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf)

This U.S. EPA report provides guidelines for conducting economic analyses of environmental policies as well as guidance for meeting the statutory and Executive Order requirements for conducting economic analyses. Organized into 10 main chapters, the report discusses a variety of economic assessment theoretical approaches and procedures as well as key analytical issues to keep in mind when performing economic analyses to support policy decisions. While the report assumes the reader has some background in microeconomics as applied to environmental and natural resource policies, it does provide a brief review of economic foundations in Appendix A and Glossary to define selected key terms.

US EPA, Office of Atmospheric Programs. Climate change in the United States: Benefits of global action. 2015.

Organization: US EPA

URL: <http://www2.epa.gov/sites/production/files/2015-06/documents/cirahealth.pdf>

This report summarizes key findings from EPA's Climate Change Impacts and Risks Analysis (CIRA) project, which quantifies and monetizes the risks of inaction and benefits to the U.S. of global greenhouse gas mitigation within broad sectors. Key findings, risks of inaction, economic and health impacts, and methodological approaches are described for the following four CIRA sectors: air quality, extreme temperature mortality, labor, and water quality.

WHO, Regional Office for Europe. Environmental health and economics: Use of economic tools and methods in environmental health. 2012.

Organization: World Health Organization (WHO)

URL: http://www.euro.who.int/_data/assets/pdf_file/0016/231532/e96937.pdf

Report summarizes conclusions from an expert, open-forum discussion on how to incorporate economics into evidence-based decision making in environmental health. Topics included how the recent economic situation is relevant for WHO and other health agencies, and how this change can benefit or hinder the environmental health agenda; identifying the priority issues and goals in connection with economics and environmental health that are suitable for assisting Member States in policy-making; and development of a draft strategic framework on environmental health economics, including areas and issues that are priorities for future pilot studies.

Books or Book Chapters

Abeygunawardena P and Asian Development Bank. Environment and economics in project preparation: Ten Asian cases. Economic evaluation of environmental impacts. 2. 1999. Asian Development Bank.

Book chapter discusses the broad issues of externalities, market failures, and irreversibilities. It explains methods for undertaking economic evaluation of environmental impacts of development projects tasks, including measures for identifying and screening impacts, valuation of environmental benefits and costs, and integration of these considerations into the project.

Birley MH. Health impact assessment: Principles and practice. 2011.

DOI Link:

http://books.google.com/books?id=1NDjz_044igC&printsec=frontcover&dq=environmental+health+economics&hl=en&sa=X&ei=U8iMU56JJ8vMsQS21oDABw&ved=0CN8BE0gBMBs#v=onepage&q&f=false

Book outlines the significance, principles, and practice of health impact assessments (HIAs). It provides valuable insights to readers from a wide range of professions about public health, health equality, and health impact.

Job CA. Groundwater economics. 2009. CRC Press.

Book explores the application of economic evaluation and cost/benefit analysis for the use, protection, remediation, and conservation of groundwater. It reviews the major economic uses of and demand for groundwater, provides an ecosystem context for resource withdrawals, discusses the application of economics to groundwater policy and decisions, and explores the economics of groundwater sustainability.

Livermore MA and Revesz RL. The globalization of cost-benefit analysis in environmental policy. Environmental impacts. 2013.

Book examines how cost-benefit analysis can help developing and emerging countries confront the next generation of environmental and public health challenges. Analysis in the book examines the growing reach of cost-benefit analysis; presents relevant case studies where cost-benefit analysis has been incorporated in the Americas, Africa, Middle East, and Asia; and includes a discussion on the conceptual and institutional issues that must be addressed in adopting cost-benefit analysis in developing and emerging countries.

Markandya A, Harou P, Bellù LG, and Cistulli V. Environmental economics for sustainable growth: A handbook for practitioners. 2002.

Handbook for trainers, practitioners, and government advisors involved in environmental policy-making is intended to enable professionals to initiate and implement environmental economic studies and identify policies and investments to ensure sustainable development in their respective countries.

McIntosh E, Clarke P, Frew E, and Louviere J. Applied methods of cost-benefit analysis in health care. 2010.

Book provides a comprehensive set of instructions and examples of how to perform a cost-benefit analysis (CBA) of a health intervention. Developed out of a course run by Jordan Louviere at the University of Technology, Sydney, entitled "An Introduction to Stated Preference Discrete Choice Modeling," it has a particular focus on the use of stated preference survey methods to identify consumer preference data, as well as the use of recent developments in cost-effectiveness analysis within a CBA framework. In doing so, the most up to date methodologies for CBA are compiled in a comprehensive manner with the aim of advancing the methodology of CBA in healthcare.

National Research Council. Valuing health for regulatory cost-effectiveness analysis. 2006. Washington, DC: National Academies Press.

Book provides useful recommendations on how to measure health-related quality of life impacts for diverse public health, safety, and environmental regulations. Considered an essential review text for public decision makers, regulatory analysts, scholars, and students in the field.

Organisation for Economic Co-operation and Development (OECD). The cost of air pollution: Health impacts of road transport. 2014. Organisation for Economic Co-operation and Development (OECD) Publishing.

DOI Link: <http://dx.doi.org/10.1787/9789264210448-en>

This book, published by the Organisation for Economic Co-operation and Development (OECD), discusses economic costs of air pollution and the implications for health and policy. Based on extensive new epidemiological studies since 2010, the book discusses methods for calculating economic costs of health impacts, and presents analyses of such costs in China, India, and other countries. From a policy perspective, results suggest that the economic benefits of reducing air pollution could outweigh the costs of ambitious air pollution mitigation programs.

Organisation for Economic Cooperation and Development (OECD) Environment Directorate. Economic valuation of environmental health risks to children. 2006. OECD Publishing.

DOI Link: http://www.keepeek.com/Digital-Asset-Management/oecd/environment/economic-valuation-of-environmental-health-risks-to-children_9789264013988-en#page1

Book proposes an overview of the main methodological problems associated with the valuation of health risks to children, including environmental risks. It intends to help policymakers better evaluate environment-related health risks that particularly affect children by providing a better understanding of the conceptual and practical problems associated with undertaking valuation studies in the case of children, and to contribute to the development of guidelines for the valuation of children's health environmental risk.