

Economics of Air Pollution and Health in Developing Countries



A Brief Literature Survey

S. Aaron Hegde

North Carolina State University

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Outdoor Air Pollution

a. Developing Countries

1. Alberini, A. and A. Krupnick (2000), 'Cost-of-Illness and WTP Estimates of the Benefits of Improved Air Quality: Evidence from Taiwan', *Land Economics* 76(1), February 2000.

Abstract: They compare cost-of-illness (COI) and willingness-to-pay (WTP) estimates of the damages from minor respiratory symptoms associated with air pollution using data from a study in Taiwan in 1991-92. A contingent valuation survey is conducted to estimate WTP to avoid minor respiratory illnesses. Health diaries are analyzed to predict the likelihood and cost of seeking relief from symptoms and of missing work. As predicted by estimates, exceeding the latter by 1.61 to 2.26 times, depending on pollution levels. These ratios are similar to those for the United States, despite the differences between the two countries.

2. Alberini, A., M. L. Cropper, T. T. Fu, A. Krupnick, J. T. Liu, D. Shaw and W. Harrington (1997), 'Valuing Health Effects of Air Pollution in Developing Countries: The Case of Taiwan', *Journal of Environmental Economics and Management* 34 (2): 107-126. (Only Abstract Available)

Abstract: A contingent valuation survey was conducted in Taiwan to elicit willingness to pay (WTP) to avoid a recurrence of the episode of acute respiratory illness most recently experienced by the respondent. We estimate a model in which willingness to pay depends on the attributes of the illness (duration and number of symptoms, and nature of the illness) and on respondent characteristics (such as income and health history), and allow mitigating behavior to be endogenously determined with willingness to pay. WTP of Taiwanese households is compared with benefits transfer extrapolations that adjust WTP for the United States by Taiwan household income, relative to U.S. household income. (c) 1997 Academic Press

3. Alberini, A. and A. Krupnick (1998), 'Air Quality and Episodes of Acute Respiratory Illness in Taiwan Cities: Evidence from Survey Data,' *Journal of Urban Economics* 44(1): 68-92. (Only Abstract Available)

Abstract: This paper reports on a unique study that records daily health status for over nine hundred residents of three urban areas in Taiwan and elicits their willingness to pay to avoid episodes of illness. Incidence of illness is related to the ambient concentration levels of particulate matter but the effects are much less pronounced than would be expected from earlier U.S. studies. Willingness to pay to avoid illness is considerably higher than that predicted by extrapolations of U.S. studies that rely on simple income adjustments. The authors argue that extrapolations from U.S. studies may be inadequate for predicting the benefits of reduced pollution levels in developing countries. (c) 1998 Academic Press

4. Aunan, K et al., (1998), 'Health and Environmental Benefits from Air Pollution Reductions in Hungary,' *The Science of the Total Environment* 212: 245-268.

Abstract: The aim of this study is to assess the cost and benefit of the implementation of a specific energy saving program in Hungary. They consider the possible reduced damage to public health, building materials and agricultural crops that may be obtained from reducing emissions of important air pollutants and also how the program contributes to reduced emissions of greenhouse gases. The measures are described in the National Energy Efficiency Improvement and Energy Conservation Programs (NEEIECP), elaborated by the Hungarian Ministry of Industry and Trade and accepted by the Government in 1994. The energy saving expected from the program is approximately 64 PJ/year. The benefits were estimated using monitoring data and population/ recipient data from urban and

rural areas in Hungary together with exposure-response functions and valuation estimates mainly from western studies. Their analysis indicates that the main benefit from reducing the concentrations of pollutants relates to public health and that reduced prevalence of chronic respiratory diseases is an important effect. Reduced premature mortality is also important and the estimated attributable risk of air pollution to excess mortality at present is approximately 6%. The estimated annual benefit of improved health conditions alone is likely to exceed the investments needed to implement the program. In addition there are significant benefits due to reduced replacement and maintenance costs for building materials (30.35 million US\$ annually in Budapest only). The damage to crops due to ozone is large, but a significant improvement in Hungary depends upon concerted actions in several countries.

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6. Chaaban, F.B., I. Nuwayhid and S. Djoundourian (2001), 'A Study of Social and Economic Implications of Mobile Sources on Air Quality in Lebanon,' *Transportation Research Part D* 6: 347-355.
7. Chestnut, L.G., Ostro, B.D. and N. Vichit-Vadakan (1997), 'Transferability of Air Pollution Control Health Benefits Estimates from the United States to Developing Countries: Evidence from the Bangkok Study,' *American Journal of Agricultural Economics* 79:1630-35.

Abstract: Countries around the world are experiencing increased level of air pollution as a result of rapid increases in energy consumption and motor vehicle use, a product of rapid population and economic growth. This paper focuses on the benefits to human health through reductions in particulate matter air pollution, a common pollutant in the urban environment. The authors summarize the results of a set of health effects and economic valuation studies conducted in Bangkok, Thailand, concerning particulate matter air pollution and highlight what these results imply regarding how transferable results from other countries are for assessing health benefits of particulate matter reductions in Bangkok. Comparing the willingness-to-pay (WTP) values from Bangkok to U.S. estimates, this study finds that Bangkok residents are willing to pay a higher share of their income to protect their health. A plausible explanation provided for this result is that health may be seen as a basic necessity like food and shelter.

8. Cropper, Maureen, et al., (1997), 'The Health Benefits of Air Pollution Control in Delhi,' *American Journal of Agricultural Economics* 79:1625-1629.

Abstract: This paper reports the results of a study relating levels of particulate matter to daily deaths in Delhi, India, between 1991 and 1994. The focus is on Delhi because it is one of the world's most polluted cities. This study concludes: (a) The impact of particulate matter on total non-trauma deaths in Delhi is smaller than effects found in the United States. (b) The impacts of air pollution on deaths by age-group may be very different in developing countries than in the United States, where peak effects occur among people aged sixty-five and older. In Delhi, peak effects occur between the ages of fifteen and forty-four, implying that a death associated with air pollution causes more life-years to be lost.

9. Cropper, Maureen, et al., (1997), 'Valuing Health Effects of Air Pollution in Developing Countries: The Case of Taiwan,' *Journal of Environmental Economics and Management* 34:107-126.
10. Dasgupta, S., H. Wang and D. Wheeler (1997), 'Surviving Success: Policy Reform and the Future of Industrial Pollution in China', World Bank Policy Research Working Paper No. 1856, October
http://econ.worldbank.org/working_papers/287/

11. El-Fadel, M. and M. Massoud (2000), 'Particulate Matter in Urban Areas: Health-Based Economic Assessments,' *The Science of the Total Environment* 257: 133-146.
12. Eskelund, G. S., (1997), 'Air Pollution Requires Multipollutant Analysis: The Case of Santiago, Chile,' *American Journal of Agricultural Economics* 79:1636-1641.
13. Gielen, D. and C. Changhong (2001), 'The CO₂ emission reduction benefits of Chinese energy policies and environmental policies: A case study for Shanghai, period 1995 – 2020', *Ecological Economics* 39: 257 – 270.
14. International Scientific Oversight Committee, K. R. Smith et. al (2004), 'Health Effects of Outdoor Air Pollution in Developing Countries of Asia: A Literature Review', Special Report #15. Health Effects Institute, Boston, April 2004.
<http://www.healtheffects.org/Pubs/SpecialReport15.pdf>
15. Krupnik, A. and A. Alberini (1997), 'Air Pollution and Acute Respiratory Illness: Evidence from Taiwan and Los Angeles,' *American Journal of Agricultural Economics* 79: 1620-1624.

Abstract: This paper explores the appropriateness of concentration-response function transfers by comparing two health studies conducted following a similar format but years apart- in Los Angeles and Taiwan. Daily records from a diary- type epidemiological study are used to fit logit equations predicting the probability of experiencing minor acute respiratory symptoms as a function of pollution and weather variables, individual characteristics, and health background and proxies for reporting effects.

16. Kwak, Seung-Jun, Seung-Hoon Yoo and Tai-Yoo Kim (2001), 'A Constructive Approach to Air-Quality Valuation in Korea,' *Ecological Economics* 38: 327-344.
17. Larson, Bruce A., et al., (1999), 'The Economics of Air Pollution Health Risks in Russia: A case study of Volgograd', *World Development* 10: 1803-1819.

Abstract: A combined health risk assessment, cost-effectiveness analysis, and benefit-cost analysis is undertaken for direct particulate emissions from 29 stationary source polluters in the city of Volgograd, Russia. Annual particulate-related mortality risk from these stationary sources are estimated to be substantial, with an estimate in the range of 960- 2,667 additional deaths per year in this city of one million. The majority of these risks are attributed to two major facilities in the northern part of the city. For several emission reduction projects, the cost-per-life saved was estimated to be quite low. The total net benefits to the city of implementing five of the six identified projects, leading to roughly a 25% reduction in mortality risk, are estimated to be at least \$40 million in present value terms.

18. Ostro, B., et al., (1996), 'Air Pollution and Mortality: Results from a Study of Santiago, Chile', *Journal of Exposure Analysis and Environmental Epidemiology* 6 (1): 97-114. (Detail version of the report as Policy Research Working Paper 1453, The World Bank, Washington DC, USA.)
19. Ostro, Bart D. et al. (1998), 'Air Pollution and Health Effects: A Study of Respiratory Illness among Children in Santiago, Chile', World Bank working paper, March 1998.
<http://www.worldbank.org/html/dec/Publications/Workpapers/WPS1900series/wps1932/wps1932.pdf>
20. Ostro, B. (1994), 'Estimating the Health Effects of Air Pollutants: A Method with an Application to Jakarta', World Bank, Policy Research Department Working Paper, No. 1301.
<http://econ.worldbank.org/resource.php>
21. Pearce, D. (1996), 'Economic Valuation and Health Damage from Air Pollution in the Developing World', *Energy Policy* 24(7): 627-630.

Abstract: Meta studies of air pollution epidemiology have resulted in the use of transferable dose-response coefficients whereby the statistical relationship between air pollution and human health is applied outside the countries of the original studies. The aim is to predict changes in premature mortality and morbidity. Some studies then apply economic valuations in order to see if health damage from air pollution should be treated as a priority concern in the countries to which the coefficients are applied. Preliminary work suggests that some forms of air pollution, notably inhalable particulate matter and ambient lead, are serious matters for concern in the developing world.

22. Ryan, O., R. E., (1996), 'Cost .Effective Policies to Improve Urban Air Quality in Santiago, Chile', *Journal of Environmental Economics and Management* 31(3): 302-313. (Only Abstract Available)

Abstract: This paper examines the applicability of market-based incentives for controlling emissions of particulate matter from fixed sources, in a developing-country context. It uses Santiago, Chile as a case study. A linear programming model has been developed to establish the costs of achieving different air quality targets using marketable permits and command-and-control (CAC) policies. The main conclusion is that an ambient permit system (APS) substantially reduces compliance costs of achieving a given air quality target at each receptor location in the city. Consequently, the use of permits is warranted. However, spatial differentiation of permits is required, thus complicating the design and use of such an instrument. Moreover, the reduction in compliance costs under APS is significantly less when the air quality targets imposed for each receptor location are the same as those achieved by other CAC policies.

23. Romieu, I., H. Weitzenfeld and J. Finkelman (1990), 'Urban Air Pollution in Latin America and Caribbean: Health Perspectives', *World Health Statistics Quarterly* 43(3): 153-167. (Only Abstract Available)

Abstract: In the last few years, air pollution has become a major issue in some countries of Latin America and the Caribbean because of urban development and growing industrialization. In addition to industrial processes often concentrated in the cities, vehicle emission and stationary-source fuel combustion are the primary sources of air pollution. Although air-quality standards have been established in some Latin American countries, these are frequently exceeded. Adverse health effects of air pollution have been mainly associated with the following pollutants: sulfur dioxide and particulate matter, photochemical oxidants, nitrogen dioxide and carbon monoxide, and lead. Short-term as well as long-term effects can be expected at levels exceeding WHO guidelines. The Latin American urban areas most affected by anthropogenic pollutant emissions are: the area of Sao Paulo (Brazil), the city of Santiago (Chile) and the metropolitan area of Mexico City. However, situations similar to those prevailing in these cities could well occur in other cities of Latin America and the Caribbean. The population exposed to air-pollutant levels exceeding WHO guidelines can be estimated to 81 million or 26.5% of the total urban population of Latin America and 19% of its total population. These estimates correspond to 30 million children (0-14), 47 million adults (15-59) and 4 million elderly people (60+). To date a very limited number of epidemiological studies have been carried out to determine the potential health effects of air pollutants in Latin America. To obtain a rough estimate, a scenario was hypothesized in which subjects living in cities would be exposed to a given level of air pollutant, using data from the international literature to extrapolate the expected number of events in different strata of the hypothetical population. The estimated health effects are considerable and warrant priority control intervention. This is true although epidemiological studies are needed to evaluate the health impact of specific pollutant compounds as well as their interactions in Latin American populations exposed to high levels of pollution.

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<http://www.epa.gov/crb/apb/publications.htm>
28. Smith, K. R. (1993), 'Fuel Combustion, Air Pollution Exposure, and Health: The Situation in Developing Countries', *Annual Review of Energy and the Environment* 18:529-66.
<http://ehs.sph.berkeley.edu/krsmith/publications/AREE-1993.pdf>
29. Thanh, B. D. and T. Lefevre (2000), 'Assessing Health Impacts of Air Pollution from Electricity Generation: The Case of Thailand', *Environmental Impact Assessment Review* 20: 137-158.

Abstract: They apply the impact pathway approach (IPA) to estimate health impacts and corresponding damage costs of sulfur dioxide (SO₂) and emissions of fine particulate matter (PM₁₀) from four power units using different fuels (lignite, oil, natural gas, and coal) at four locations in Thailand. The results show that the damage cost related to health effects of electricity generation in Thailand are relatively small, but not negligible, ranging from 0.006 U.S. cent to 0.05 U.S. cent per kilowatt-hour (in 1995 dollars). Damage costs to the public health due to SO₂ and PM₁₀ emissions from electricity generation not only depend on fuel and generating technology but also depend strongly on power plant location. This implies that the assessment of adverse health impacts is very important for technology choice and siting of new power plants.

b. Developed Countries

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Abstract: Motor vehicles have significantly larger health costs than previously reported. Particulates are the most damaging pollutant, while ozone and other pollutants have smaller effects. Diesel vehicles cause more damages per mile than do gasoline vehicles, because of greater particulate emissions. Very fine particles appear more dangerous than larger particles, and combustion particles appear more dangerous than road dust. The possibility cannot be ruled out that ozone is linked to mortality and chronic illness, effects which are costly and would considerably raise the costs of ozone pollution. These results suggest that emphasis should be placed on the regulation of particulates.

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Abstract: Intermittent operation of a steel mill in a mountain valley in central Utah provides a unique opportunity to measure the external health costs of air pollution. A nearby valley provides a control. This paper analyzes data on hospital admissions and daily deaths for the two valleys, using negative binomial regression models of daily hospital admissions and deaths. Hospital admissions for respiratory diseases increase significantly when the mill is in operation. Mortality also increases during mill operation. Estimated excess hospitalization costs are about 2 million dollars per year, and the increased cost of mortality exceeds 40 million dollars per year.

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Indoor Air Pollution

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<http://ehs.sph.berkeley.edu/krsmith/admin/pubs/Bruce%20et%20al%20IA021.pdf>
44. Caceres, D., M. Adonis, G. Retamal, P. Ancic, M. Valencia, X. Ramos, N. Olivares and L. Gil (2001), 'Indoor air pollution in a zone of extreme poverty of metropolitan Santiago', *Revista Medica Chilena* 129:33-42. (Only Abstract Available)

Abstract: Few studies have been done on indoor air pollution in areas of extreme poverty in developing countries. In such countries, for economic reasons, people use solid fuel for cooking and heating fuels which by incomplete combustion generate high levels of toxic pollutants. These represent an important risk factor for human health. We have investigated the levels of carbon monoxide (CO), sulphur dioxide (SO₂), respirable particulate matter (PM₁₀), polycyclic aromatic hydrocarbons (PAHs) and mutagenicity in the PM₅ fraction, as well as temperature and humidity, in the interior of 24 houses in La Pintana, Santiago. In addition, we have conducted a survey about symptoms, signs and respiratory diseases possibly associated with socio-economic factors in the area. The survey showed that in children younger than 2 years, most respiratory diseases occur during winter (75%), the most frequent complaint being bronchitis (62%) and obstructive bronchitis (50%). The higher pollutant concentrations were observed during heating hours, in houses that used coal (mean PM₁₀ 250 µg·m⁻³, CO 42 ppm, SO₂ 192 ppb) or firewood (mean PM₁₀ 489 µg·m⁻³, CO 57 ppm, SO₂ 295 ppb). PAHs were detected in all houses and we concluded that they came from inside the house and not from outdoor infiltration. Coal, firewood and cigarette smoke were important sources of mutagenic and carcinogenic PAHs, whereas kerosene and gas contributed mainly to the non-carcinogenic PAH fraction. In the houses studied, the population was exposed to levels of toxic pollutants that are much higher than those found outdoors in the highly polluted city of Santiago. In addition, overcrowding, excessive indoor humidity, very low indoor temperatures when the heating system was turned off, the presence of domestic animals, cats and dogs indoors and general lack of hygiene (with

attendant bacteria and fungi) are risk factors to explain the high incidence of respiratory diseases in children.

45. Campbell, H. (1997), 'Indoor air pollution and acute lower respiratory infections in young Gambian children', *Health bulletin* 55: 20-31.

Abstract: In a rural population-based cohort study of approximately 500 Gambian children under five years old followed for one year, incidence of acute lower respiratory infections (ALRI) was related to various risk factors including parental smoking and regular carriage on the mother's back while cooking, a proxy measure for exposure to smoke from cooking fires. Two statistical analyses using a 'child-weeks at risk' approach were carried out, including and excluding multiple disease episodes in the same child. Weekly surveillance for ALRI found 75 episodes in 62 children. Stratified analyses using both approaches suggested father's smoking, and, for girls only, carriage on the mother's back while cooking and being part of a polygamous family were the main risk factors associated with infection: when multiple episodes occurring in the same child were excluded, not having a health card was an additional risk factor in children over a year old. Multiple logistic regression modelling of data from both approaches, including each of these risk factors and sex, age, village and season, suggested father's smoking, carriage on the mother's back while cooking and being part of a polygamous family increase risk of ALRI, the latter two for girls only. The analysis excluding multiple episodes in the same child also suggested that not having a health card is a risk factor for children aged 1-5 years. The difficulties in interpreting these findings are discussed.

46. Chen, A. and E. L. Vine (1999), 'A Scoping Study on the Costs of Indoor Air Quality Illnesses: An Insurance Loss Reduction Perspective', *Environmental Science and Policy* 2: 457-464.

Abstract: The number of indoor air quality (IAQ)- related health complaints in commercial buildings, and the frequency of litigation over the effects of poor IAQ is increasing. These increases have ramifications for insurance carriers, which pay for many of the costs of health care and general commercial liability. However, insurance companies know little about the actual costs from poor IAQ in buildings. This paper reports on the results of a literature search of buildings-related, business and legal databases, and interviews with insurance and risk management representatives aimed at finding information on the direct costs to the insurance industry of poor building IAQ, as well as the costs of litigation. The literature search turned up little specific cost information, but indicated that there is strong awareness and growing concern over the .silent crisis. of IAQ and its potential to cause large industry losses. The source of these losses includes both direct costs to insurers from paying health insurance and professional liability claims as well as the cost of litigation. In spite of the lack of data on how IAQ-related health problems affect their business, the insurance industry has taken the anecdotal evidence about their reality seriously enough to alter their policies in ways that have lessened their exposure.

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Abstract: In the last decade, a number of quantitative epidemiological studies of specific diseases have been done in developing countries that for the first time allow estimation of the total burden of disease (mortality and morbidity) attributable to use of solid fuels in adult women and young children, who jointly receive the highest exposures because of their household roles. Few such studies are available as yet for adult men or children over 5 years. This paper evaluates the existing epidemiological studies and applies the resulting risks to the more than three-quarters of all Indian households dependent on such fuels. Allowance is made for the existence of improved stoves with chimneys and other factors that may lower exposures. Attributable risks are calculated in reference to the demographic conditions and patterns of each disease in India. Sufficient evidence is available to estimate risks most confidently for acute respiratory infections (ARI), chronic obstructive pulmonary disease (COPD), and lung cancer. Estimates for tuberculosis (TB), asthma, and blindness are of intermediate confidence. Estimates for heart disease have the lowest confidence. Insufficient quantitative evidence is currently available to estimate the impact of adverse pregnancy outcomes (e.g., low birthweight and stillbirth). The resulting conservative estimates indicate that some 400-550 thousand premature deaths can be attributed annually to use of biomass fuels in these population groups. Using a disability-adjusted lost life-year approach, the total is 4-6% of the Indian national burden of disease, placing indoor air pollution as a major risk factor in the country.

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Abstract: Four different methods have been applied to estimate the burden of disease due to indoor air pollution from household solid fuel use in developing countries (LDCs). The largest number of estimates involves applying exposure-response information from urban ambient air pollution studies to estimate indoor exposure concentrations of particulate air pollution. Another approach is to construct child survival curves using the results of large-scale household surveys, as has been done for India. A third approach involves cross-national analyses of child survival and household fuel use. The fourth method, referred to as the 'fuel-based' approach, which is explored in more depth here, involves applying relative risk estimates from epidemiological studies that use exposure surrogates, such as fuel type, to estimates of household solid fuel use to determine population attributable fractions by disease and age group. With this method and conservative assumptions about relative risks, 4-5 percent of the global LDC totals for both deaths and DALYs (disability adjusted life years) from acute respiratory infections, chronic obstructive pulmonary disease, tuberculosis, asthma, lung cancer, ischaemic heart disease, and blindness can be attributed to solid fuel use in developing countries. Acute respiratory infections in children under five years of age are the largest single category of deaths (64%) and DALYs (81%) from indoor air pollution, apparently being responsible globally for about 1.2 million premature deaths annually in the early 1990s.

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1 sahegde@unity.ncsu.edu

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