EVALUATING THE HEALTH COST OF TRANSPORT POLLUTION

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ABSTRACT :

Rapid urban growth and industrialization has degraded urban ecosystem. Out of several urban ecosystem components impact on ambient air quality is more perceptible. Amongst the several sources of urban air pollution the share of vehicular exhaust emission is rising, over time, in many Indian cities; this is due to increasing vehicular population. Carbon monoxide, oxides of nitrogen and particulate matter present in the exhaust of a vehicle cause major health impact on the urban population. High concentration of these pollutants in the ambient environment of the congested road stretches causes pulmonary diseases. To design any policy to mitigate urban transport pollution estimation of health costs is a prerequisite. In developing country like India very little comprehensive research has been conducted to estimate health cost of urban transportation. Literatures on health costs due to emission of pollutants from different modes of vehicles are largely dependent on studies conducted in United States. Absence of epidemiological studies, in India, on urban transport has compelled the researchers to transfer the benefits of such studies to Indian transport sector. Transport economists, in India, have used transfer of benefit method to

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estimate health cost based on US research studies. In such studies adjustments have been made on certain parameters like demography, income and currency purchase power between the two countries. However, appropriateness of such benefit transfer will remain important because of cultural dependence on methodology adopted on health cost estimate, which cannot be neutralized by such adjustments. In this paper, based on available data from different research publications the health costs arising out of transport pollution are estimated for different traffic flows in Kolkata. Emission rates of various pollutants from different vehicle modes are also collected to derive the aggregate pollution for a particular traffic flow. Survey reports on traffic flow in Kolkata is also used to ascertain the modal splits in a particular traffic flow Finally, the health cost estimated in this paper are used to examine how far shift in passenger's modal choice reduced the aggregate health cost in a congested road stretch. Under this context policy implications designed to shift passengers using personal vehicle to mass transport modes is also discussed.

Keywords: Emission coefficient, vehicle-kilometer, modal split.

Introduction :

The urban population in India has increased significantly from 62 million in 1951 to 1.21 billion in 2011 and is estimated to grow to around 540 million by the year 2021. Out of total population, the urban population has gone up from 17% in 1951 to 31.16% in 2011 and is expected to increase up to around 37% by the year 2021. Consequently, the number and size of cities have also increased considerably, although, circumstances differ considerably across cities in India. However, certain basic trends, which determine transport demand, for example, increase in urban population, rise in household income, and augmented industrial and commercial activities, are similar amongst the cities.

At present, India is facing various challenges to meet its socioeconomic development priorities. Some of the socioeconomic issues are poverty reduction, urban growth, infrastructure and environmental quality. In the next decade, unprecedented scale of urban growth in India's metropolitan areas will be witnessed. India's current urbanization rate is still low, which was only 30% in 2008 (World Bank, 2010), but is increasing rapidly. It is projected that India will take over China to become the most populous country by 2030 while urban population will then double. As per UNDP's report (2007) more than 320 million rural population will migrate to the cities during the period from 2000 to 2030 period. This implies that there will be huge increase in demand for urban infrastructure, and transport, in particular, during this period. The above demographic changes have placed heavy demands on urban transport systems; a demand that many Indian cities have been unable to meet. The main reason for this is the prevailing imbalance in modal split, besides inadequate transport infrastructure, and its sub-optimal use. Public transport systems have not been able to keep pace with the rapid and substantial increases in demand over the past few decades. Indian economic boom has in its wake provided a great opportunity for an urban dweller to acquire personalized modes. Consequently, there is a modal shift towards personal vehicles, and taxis. This adds to further traffic congestion in Indian cities. Private car ownership in many large Indian cities increased significantly. The urban road chaos is increasing day by day with ever increasing car ownership. Automobile ownership growth rates are of the order of fifteen to twenty percent per annum in most Indian cities. Per capita travel by cars in 23 urban areas was 331 passenger kilometer (pkm) in 2005. Out of several urban areas in India, the city of Delhi recorded a markedly high level of 894 pkm in 2005. (Reddy and Balachandra, 2010)

The substantial increase in personalized mode of transport, as cited in the earlier subsection, has contributed significantly to the deterioration of the urban air quality in India..

According to UNEP, urban air pollution is estimated to cost approximately five to twenty percent of GDP in developing countries. And more specifically, over 90% of air pollution in cities in these countries is attributable to vehicle emissions brought about by high number of older vehicles coupled with poor vehicle maintenance, inadequate infrastructure and low fuel quality (UNEP, 2005). Air quality is worse in the large metropolitan cities like Kolkata, Delhi, Mumbai, Chennai, etc. Table 1 reveals the pollution load in different cities. It is worth mentioning here that the city of Delhi started to implement an initiative of moving public transport to compressed natural gas (CNG) in 2001, and this contributed to substantial improvements of local air quality and reduction in ambient air concentration of pollutants such as CO, SO2, suspended particulate matter (PM) and NOx (Goyal 2003). As per CPCB report (2010), during the period 2003 to 2004, total transport emission of CO_2 was 258.10 Tg. Out of which CO_2 contribution of road sector was 243.82 Tg {1 Tg = 1 million tonnes), that is, 94.5%. Road sector contributes 32.57 Tg (45.1%) of CO. Among different type of vehicles, trucks and lorries contribute 28.8% CO2 (70.29 Tg), 39%

NOx (0.86 Tg), 27.3% SO2 (0.19 Tg), and 25% particulate matter(0.03 Tg), which constitute 25% of the total vehicular emission of India. Similarly two wheelers are major source of CO (0.72 Tg; 23.7%), CH4 (0.06 Tg; 46.4%), and HC (0.46 Tg; 64.2%) and buses are emitting NOx (0.68 Tg; 30.7%) and PM (0.03 Tg; 20.5%). The pollutants stated above, which are emitted from vehicles cause major health impacts on urban population . The health impact caused by concentration of these pollutants in the ambient atmosphere is increase in incidence of pulmonary diseases. To suggest a broad policy framework estimation of health cost is a prerequisite . In developing countries, like India, no significant research on health cost estimation of transport pollution is available. In this paper, based on available data from different research publications health costs arising out of transport pollution are estimated. At the outset paper existing research on transport pollutants and its health impacts are discussed. Next, health costs arising out of transport pollution are estimated for different traffic flows in Kolkata. Finally, shift in passenger's modal choice on health cost in a congested road stretch and certain broad policy implications are examined.

Table 1 Estimated Pollution Load in the cities (2002)

City	**Pollution Load in Metric tones per day**			
	CO	**NOx**	**HC**	**PM**
Mumbai	**189.55**	**46.37**	**89.93**	**10.58**
Kolkata	**137.50**	**54.09**	**47.63**	**10.80**
C177.00	**27.30**		**95.64**	**7.29**
Bangalore	**207.04**	**29.72**	**117.37**	**8.11**
Hyderabad	**163.95**	**36.89**	**90.09**	**8.00**
Kanpur	**28.73**	**7.25**	**11.70**	**1.91**
Agra	**17.93**	**3.30**	**10.28**	**0.91**

Source: Auto Fuel Policy, 2002, Ministry of Petroleum & Natural Gas

Impacts of urban transport on health :

According to studies by Central Pollution Control Board (CPCB), 76.2% of CO, 96.9% of hydrocarbons, and 48.6% of NOx are caused by emissions from the transport sector in certain Indian cities. Epidemiological studies have shown that there is a significant association between the concentration of air pollutants and adverse health impacts (Ostro, et al., 1995; MJA, 2004). Among the different types of air pollutants, suspended particulate matter (SPM), especially Respirable Suspended Particulate Matter (RSPM), is recognized as the most important in terms of health effects. It can penetrate deep into the respiratory tract and cause an increase in cardiac respiratory illnesses, even mortality; contribute to daily prevalence of respiratory symptoms; and decrease pulmonary lung function in children and adults. (COMEAP, 1998; M.El-Fadel and M. Masood, 2000; CEAP, 2004). Very fine particulates like PM10 or PM2.5 being more dangerous than larger particulates, the combustion of fuel like high speed diesel (HSD) has become a greater danger for human health than apparently more visible source of road dust (Dockery et.al. 1993;Marrack 1995; Pope et. al., 1995). The importance of the link between air pollution and health is indicated in a study by Pope, et al., (2002) who show that residents who live in an area, in California, that is severely impacted by particulate air pollution are at a greater risk of lung cancer at a rate comparable to nonsmokers exposed to second-hand smoke. It is observed in this study that there is an excess risk of approximately sixteen percent dying from lung cancer due to fine particulate air pollution. The studies of Small and Kazini (1995), Krupnick et. al. (1997) and Delucchi and McCubbin (1999) point to the relative importance of automotive pollution in determining urban air quality and their health cost implications.

In one study Delucchi and McCubbin (1996) has adopted micro-environment estimation approach. The epidemiological literature, on the other hand, suggests that air pollution causes a variety of effects including eye irritation, headaches, acute and chronic respiratory illness, and death. In particular, the most serious health impacts include a significant reduction in life expectancy, and premature death, both of which are strongly linked to exposure to particulate matter (Forsberg et al 2005). Most of the existing studies on air pollution and health are based on the physical linkage approach, where a dose response function is estimated in order to observe the relationship between human health and air pollution. Ostro (1983; 1987), estimated dose response functions to observe the effect of air pollutants on morbidity and showed that particulates affect both restricted activity days (RAD) and work loss days (WLD). His work suggests that one percent increase in particulate matter will increase WLD by about 0.5% and RAD by 0.4%.Another study worth mentioning here is that by Chestnut, et al, (1997) who compared the results of various studies on health effects and economic valuation conducted in Bangkok, Thailand, concerning particulate matter air pollution. The study compares the willingness to pay for air quality improvements between Bangkok and the US and finds that Bangkok residents are willing to pay a higher share of their income to protect their health. A tentative but plausible explanation given here is that health is seen as a basic necessity at par with food and shelter.

Health cost estimation in Indian transport sector :

There have been relatively very few comprehensive studies on the health damage cost of air pollution in the Indian context. The literature on health impacts of pollution, both technical and economic, is largely dependent on researches carried out in the United States. Based on the USA data, Keeler and Small's study is one of the most influential and widely cited works on the costs of automobile use. In particular, it is one of the first attempts to quantify the non-market costs of automobile use, such as time cost, maintenance cost. However, most of the costs reported in this study are now outdated, and many of the methods have been improved (Murphy & Deluchhi, 1997). European studies for estimating the health effect of environmental quality are also heavily dependent on US research (Holland, Berry, and Forste, Extern E Project, 1999). In order to transfer the benefit of such studies to Indian transport sector adjustments have been made on certain parameters like demography, income and currency purchase power between the two countries. However, appropriateness of such benefit transfer will remain important because of cultural dependence on methodology adopted on health cost estimate, which cannot be neutralized by such adjustments. (Sengupta & Mandal 2002). A tentative estimate of health costs of urban air pollution in India was estimated to be US $1.4 billion (Brandon and Homman, 1995). Delucchi (2000) used broadly a household health production function approach and they monetise the health damage by using the estimates of cost of illness due to loss of income for working days lost, cost of treatment, etc. which have in turn been based on the judgmental values based in large part on the works of Krupnick (1988), Krupnick and Kopp (1988), Krupnick and Cropper (1992), and Delucchi and McCubbin (1996).

According to Centre for Science and Environment (CSE), the quantity CO, hydrocarbons, and nitrogen oxides have increased with a reduction in motor vehicle speeds. For example, at a speed of 75 km/h, emission of CO is 6.4 g/veh.-km, which increases fivefold to 33.0 g/veh.-km at a speed of 10 km/h. Similarly, emission of hydrocarbons, at the same speeds, increases by 4.8 times from 0.93 to 4.47 gm/veh.-km. Thus, traffic congestion not only decreases the vehicle speed but also increases the pollution level. . In a recent study in India, Murty, et al., (2003) use household data to analyze the impact of higher level of suspended particulate matter (SPM) in the Indian metropolitan cities of Delhi and Kolkata. Using the three stage least square method, a system of simultaneous equations consisting of the health production function and the demand functions for mitigating and averting activities are estimated. The study reveals that the annual marginal benefits to a typical household is Rs 2086 in Delhi and Rs 950 in Kolkata if the level of SPM is reduced from the current average level to the prescribed safe level. **A** study of the city of Kanpur (Gupta 2004) showed that the annual welfare gains to a working individual from reduced air pollution are Rs 130.39 due to reduction in workdays lost and due to the reduced medical expenditures is Rs 34.43 to a person. This, constitute a total gain of Rs 212.82 million per annum to the population of the city of Kanpur (Gupta U, 2006). The emissions for a given inventory of vehicles for their respective distances traveled can be derived for each type and model of vehicles, once this emission rates for the different models and engine designs are given per kilometre of distance travelled. The European Union, in its wide ranging Extern-E study to quantify the economic effects of air pollution, concluded that the total social cost to EU member states was equivalent to between one and two per cent of GDP (85 to 170 billion Euros) Delucchi's work from which Sengupta and Mandal (2002) draw upon for the transfer of the benefits of health cost estimation done in USA to estimate health cost arising out of automobile transportation in India is not based on any scheme of contingent valuation survey. Unlike in the case of water, there is in fact no market for clean air which may provide price signal and can be used as a benchmark reference by one who is to respond to the queries of contingent valuation survey. This gives the rationale for relying on the observed market approach for the valuation of health damage due to air pollution. In this paper health costs arising out of urban transportation estimated by Sengupta and Mondal (2002) is used. The average peak hour speed in Indian cities is far less than the optimum one[1].

Study Area :

Kolkata situated in eastern India, is largest mega city in India. The 2011 census results of West Bengal revealed that the population of Kolkata as on March 1 was 44.86 lakh The city is nodal center for local, regional, national and international traffic and transportation and other economic activities (Kansal& Sibal). The public transport system in Kolkata consists of suburban rail and metro rail, tram, bus and ferry services. The total public transport passenger trips by different modes can be summarized as follows.

Table 2:Movement of passengers within Kolkata

Mode	Volume of passengers (in lakhs)
Private bus	85
Public bus	12.50
Minibus	12.50
Tram	2
Ferry	2.40
Chartered bus	2.70
Suburban rail	32.50
Metro rail	2
Circular rail	.20
Taxi	11
Auto rickshaw	16.50
Cycle rickshaw	7.50
Total	187

Source: CMDA (2001)

In addition to this Kolkata has an elaborate transport network that causes pollution. There are multifarious transport modes used in the city - among motorized forms of transport, the city has buses, trams, autos (or three-wheelers), taxis, shared taxis, the metro, a circular rail, water-ferries and local trains for public transport, and there are two wheelers and cars for private transport.

Due inadequate road space and traffic congestion arises in different parts of the city during peak hours. The level of traffic congestion on the urban transport network is found to vary with time of the day, the maximum being during peak hours when journeys to and from work places work. Besides causing irritation, delay and environmental pollution, congestion is responsible for enhanced out of pocket expenses and consequent economic losses in the form of time losses. It has been pointed out earlier that the average speed of a vehicle in the peak hour period is 14 Km/hour and maximum speed is 25 Km/hour. A slow movement of vehicle will emit more with the consequent adverse effect on the ambient air quality. The major pollutants emitted from the vehicle are suspended particulate matter (SPM), oxides of nitrogen (NO_X), carbon mono oxide (CO). These pollutants can cause increased mortality, morbidity, deficits in pulmonary functions (HC), cardio vascular (SPM, NOX) diseases (UNEP, 1992). The direct human health effects of air pollution vary according to both the intensity and duration of exposure and also with the health status of population exposed.

Health cost estimation :

Data :

Health cost is estimated for different traffic flows. Hypothetical flows are taken into consideration for the purpose of analysis; however, modal split data is collected from traffic flow survey conducted in Kolkata. (Table 3). In Table 4 modal splits of different traffic flows are based on survey data shown in Table 3. Inventories of emission of different pollutants emitted from various traffic flows are estimated from emission coefficients available from research papers. In Table 5 emission coefficients of different pollutants emitted from various transport modes are expressed in kg/km. Health cost estimate for Kolkata, in Rs / kg, is based on research publication (Table 6). In the research work by Sengupta and Mondal (2002), as discussed in the preceding subsection, benefits of studies conducted in USA are transferred to the context of Kolkata. Table 7 provides the health cost estimate for different traffic flows in Kolkata.

Mode of transport	Percentage in the total traffic flow
Private Bus	0.162%
Public Bus	0.33%
Mini bus	0.33%
Chartered bus	0.46%
Taxi	4.78%
Auto	5.44%
Private car	32.64%
Two wheeler	54.40%

Table 3

Modal split in a traffic flow

Traffic Flow per hour	Total Bus	Total Car	Three Wheelers	Two wheeler
573	87	187	27	272
1146	173	374	54	544
1719	260	561	82	816
2292	346	748	109	1088
2865	433	936	136	1360
3437	520	1123	163	1632
4010	606	1310	190	1904
4583	693	1497	218	2176

Source Traffic survey from report of CMDA 2001

Table 4 : Modal splits in traffic flow

Traffic Flow per hour	Total Bus	Total Car	Total 2 wheeler	Auto	Total health cost
573	87	187	272	27	23.3
1146	173	374	544	54	46.7
1719	260	561	816	82	70.04
2292	346	748	1088	109	93.40
2865	433	936	1360	136	116.74
3437	520	1123	1632	163	140.10
4010	606	1310	1904	190	163.44
4583	693	1497	2176	218	186.80

Table 5 : Emission Coefficients

Vehicle type	CO	HC	NO_X	PM
Two wheeler*	0.0014	0.00132	0.00008	0.00005
Three wheeler*	0.00245	0.00075	0.00012	0.00008
Car**	0.001	0.000125	0.000127	0.000016
Taxi**	0.001	0.000125	0.000127	0.000016
Bus**	0.0014	0.00039	0.0049	0.00022

***2005 norms**

**** Euro IV**

Table: 6 Health Cost of pollutants (Rs/kg) for Kolkata

CO	HC	NO_X	PM
.0013	1.92	30.92	248.36

Table 7 Health cost estimate for different traffic flows

Percentage increase in number of bus in the traffic flow	Percentage in reduction in health cost
2%	1.80%
5%	4.50%
10%	9.10%
15%	13%
20%	18%

Table 8 : Table showing occupancy in different modes of transport

Sl No	Mode of transport	Number of passengers/vehicle
1	Public Bus	52

2	**Private Bus**	**52**
3	**Mini Bus**	**40**
4	**Chartered Bus**	**70**
5	**Taxi**	**4**
6	**Auto**	**4**
7	**Private car**	**4**
8	**Two wheeler**	**2**

Analysis and discussion of results

In Table 3 it is shown that out of the total traffic flow 54.4 % is two wheelers. It can be also seen from Table 5 that in case of two wheelers the emission of pollutant is quite high often comparable to other transport modes whose occupancy is higher than two wheelers. The results of this analysis are used to find out the effect on health costs if policies are framed to induce the passengers to use mass transport instead of two-wheeler. In this analysis two, five, ten, fifteen percent and twenty percent increase of buses in the traffic flow is considered (Table 8). With increase in buses two wheelers, in the total traffic flow. are reduced proportionately The results show that there is significant reduction in health cost. As per Table 8 the occupancy of different modes of transport is indicated as per traffic survey data. As the occupancy in buses is considered as 52 passengers with increase of one in the traffic fleet two wheelers can be proportionately reduced. In the analysis it is also found that by modal shift to mass transport from two wheelers there has been 13 % reduction in particulate matter, about thirty percent reduction in emission of carbon monoxides and hydrocarbons (Figure1).

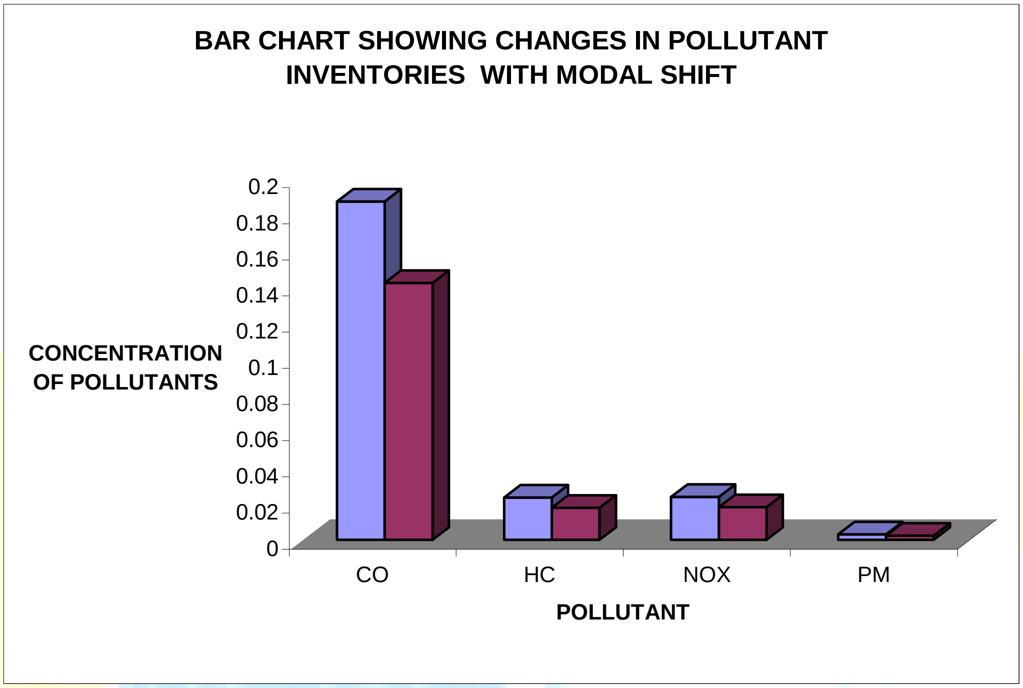

Figure 1

A separate analysis is also carried out in which it is found that with 5% increase in bus fleet and by reducing proportionately automobiles in the traffic flow health costs related to hydrocarbon and particulate matter has reduced by 21% and 42% respectively.

Conclusion :

Absence of epidemiological data has compelled the transport economists in India to transfer some benefits of studies carried out in USA to Indian urban transport sector. In this paper based on the available research works and traffic flow survey data an attempt has been made to examine how far any policy aimed at shift of passengers preference to mass transport helps to reduce emission of pollutants from vehicular exhausts as well as health cost. This analytical method can be used for study of implications of policy designs to reduce urban pollution arising out of urban transportation.

References:

- Krupnick, Alan 1988. A Health Benefit Analysis of Reductions in Photochemical Oxidants in the North Eastern United States, US Environmental Protection Agency (EPA).
- Krupnick Alan and R.J. Kopp, 1988. "The Health and Agricultural Benefits of Reductions in Ambient Ozone in the United States," US Congress: Office of Technology Assessment.
- Krupnick Alan and Maureen Cropper, 1992. "The Effects of Information on Health Risk Valuation," Journal of Risk andUncertainty, Vol 5;29-48.
- Delucchi Mark A. 2000. "Environmental Externalities of MotorVehicles Use in the U.S.," Journal of Transport Economicsand Policy, 34(2); 135-168.
- Delucchi M.A. and D. McCubbin, 1999. "The Health Cost of Motor-Vehicle – Related Air Pollution," Journal of TransportEconomics and Policy, 33(3).
- Delucchi, M.A. and D. McCubbin, 1996. "The Contribution of Motor Vehicles and Other Sources to Ambient Air Pollution,"Report No.16 in the series, The Annualised Social Cost of Motor Vehicle Use in the United States, August 1996..
- CMIE (2000), Profiles of Districts, Centre for monitoring Indian Economy Private Limited, Mumbai.
- Committee on the Medical Effects of Air Pollutants (COMEAP) (1998), "The Quantification of the Effects of Air Pollution on Health in the United Kingdom,"(http//www.doh.gov.uk.html).
- Sibal V. and Sachdeva Y. Urban Transport Scenario in India and Its Linkages with Energy and Environment. Urban Transport Journal, Vol. 2, No. 1, March 2001, pp. 34-55.
- Urban Statistics. Central Pollution Control Board, New Delhi, October 1996
- Sengupta R & Mondal s (2002): Health Damage Cost of Automotive Air pollution : Cost Benefit Analysis of Fuel Quality Upgradation for Indian Cities. www.nipfp.org.in/working_paper/wp05_nipfp_039.pdf
- Sengupta R. Sustainable Transport Pricing in India. Asian Institute of Transport Development, New Delhi, 2001, pp. 80.
- Maureen L. Cropper, Nathalie B. Simon, Anna Alberini, Seema Arora, P. K. Sharma. The health benefits of air pollution control in Delhi. American Journal of Agricultural Economics. 1997 Dec.; 79(5): 1625-1629

- Forsberg B, Hansson HC, Johansson C, Areskoug H, Persson K, Järvholm B. Comparative health impact assessment of local and regional particulate pollutants in Scandinavia. Ambio. 2005;34:11–19.
- WHO Report European Centre for Environment and Health. Bonn, Germany; 2006. Health risks of particulate matter from transboundary air pollution. WHO's Task Force Report for Europe.
- Keeler T, Small KA. The Full Costs of Urban Transport, part III, "Automobile Costs and Final Intermodal Comparisons" monograph 21, Institute of Urban and Regional Development, University of California, Berkeley. 1975.
- Murphy JJ, Delucchi MA. Review of some of the literature of the societal cost of Motor-vehicle Use 1997. Report #3 in the series. The annualized societal cost of Motor-vehicle use in the United States based in 1990–1991 data. Institute of Transportation Studies, University of California Davis;
- Alberini, A and A Krupnick (1997), "Air Pollution and Acute Respiratory Illness: Evidence from Taiwan and Los Angeles," American Journal AgricultureEconomics, (79. 7): 1620-1624.
- Alberini, A and A Krupnick (2000), "Cost of Illness and Willingness to Pay Estimates of the Benefits of Improved Air Quality: Evidence from Taiwan," Land Economics , (76): 37-53.
- Alberini, A, M Cropper, et al., (1997), "Valuing Health Effects of Air pollution in Developing Countries: the Taiwan Experience," Journal of EnvironmentalEconomics and Management, (34): 107-26.
- Brandon, C. and K. Hommann, 1995. "The Cost of Inaction: Valuing the Economy-wide Cost of Environmental Degradation in India," Presented at the Modelling GlobalSustainability conference at the United Nations University,Tokyo, Japan.
- Chestnut L., B.D. Ostro, and N. Vichit-Vadakan, 1997. "Transferability of Air Pollution Control Health BenefitsEstimates from the United States to Developing Countries:Evidence from the Bangkok Study," American Journal ofAgricultural Economics Vol. 79;1630-1635.

- Cropper, Maureen, Nathalie B Simon, A Alberini, Seema Arora, and P K Sharma (1997), "The Health Benefits of Air Pollution Control in Delhi," American Journal ofEconomics, (79.No.5): 1625-1629
- M.El-Fadel and M Masood (2000), "Particulate Matter in Urban Areas: Health-based Economic Assessment," The Science of the Total Environment, (257): 133-146.
- Murty, M N and Surender Kumar (2003), Environmental and Economic Accounting forIndustry, New Delhi: Oxford University Press.
- Murty, M N, S C Gulati and A Banerjee (2003), "Health Benefits from Urban Air Pollution Abatement in the Indian Subcontinent," Discussion Paper no. 62/2003, Delhi:Institute of Economic Growth, IEG Website.
- Ostro, B et al., (1995), "Air Pollution and Mortality: Results from Santiago, Chile," Policy Research Department, Working Paper 1453, Washington, D C: World Bank.
- Pope III, C A, et al., (2002), "Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution," Journal of the American MedicalAssociation, (287): 1123-1141.
- Pope III, C A, et al.,(1992), "Daily Mortality and PM-10 Pollution in Utah Valley,"Archives of Environmental Health, (42.3): 211-17.