SCHOOL OF ECONOMICS AND MANAGEMENT
Lund University

Societal Costs Associated with Air Pollution Related Ill-health: A Review of Methods and Results

Prepared by

Tanjima Pervin
Department of Economics
Lund University
Sweden

Supervisors

Professor Carl-Hampus Lyttkens
Department of Economics
Lund University
Sweden

Professor Ulf-G. Gerdtham
Health Economics Program (HEP)
Department of Clinical Sciences Malmö,
Lund University
Sweden

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Table of Contents

LIST OF TABLES

Abstract

The aim of the paper is to provide a systematic review of the estimation of cost-of-illness (COI) due to air and noise pollution related ill-health. The methodology used for the review includes a systematic search on electronic databases for peer-review published literature and manual searches for the identification of unpublished literature. Searches are based on the major electronic databases such as EconLit, PubMed and International Bibliography of the Social Sciences (IBSS) and the WB. While the included studies conducted in different countries, for simplicity, we separate the studies whether they are from OECD countries or otherwise, along with their publication status (published in peer-reviewed journal or not). Following the selection criteria, in total 12 studies where 5 studies from OECD countries (2 unpublished) and 7 from non-OECD countries (2 unpublished) are included in the review. No COI study is found on noise pollution related ill-health. A majority of the studies look health impact of air pollutant PM_{10}. In the estimation of COI, most of the studies consider both direct health care cost and the cost of productivity losses either due to mortality or morbidity or both but not intangible cost. The results of the COI studies show considerable variation, in part due to variations in pollution exposure levels and estimation methods particularly, cost estimations largely depend on the countries demographic compositions, health care systems and obviously included cost components. Although difficult to compare total COI across countries, however, it seems that a huge societal cost (e.g. 3.4% of GDP in Singapore and 1% of GDP in Jakarta) is concerned in with air pollution related health hazards. To increase awareness towards illnesses and conditions related with air pollution and to stimulate the policy debate on efficient allocation of resources, future research efforts should be directed towards theoretically sound and comprehensive COI studies with use of rich data (e.g. longitudinal and experimental data).

Keywords: air pollution; ill-health; societal costs; systematic review

1. INTRODUCTION

Air and noise pollution are the most serious environmental problems in urban areas around the world. The rapid process of urbanization and extensive energy utilization mostly due to rapid economic expansion and rise population over the past few decades has made urban air pollution a growing problem (Srivastava & Kumar, 2001). The air contains varying levels of pollutants exposed from motor vehicles, industry, housing and commercial sources. A number of studies have shown that air and noise pollution adversely affects human health. It is acknowledged that the impacts of five criteria pollutants, namely, carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (especially PM_{10} and $PM_{2.5}$), sulphur dioxide (SO_2) and ozone effects on health severely (Currie & Neidell, 2004). Epidemiological evidence shows that various health effects, including morbidity and mortality from respiratory and cardiovascular diseases, are strongly associated with such air pollutants (National Board of Health and Welfare, 2004). Carbon monoxide bonds with hemoglobin more easily than oxygen, so that it reduces the body ability to deliver oxygen to organs and tissues. Many people who have respiratory problems in any case, CO may be harmful to them. Nitrogen dioxide reactive gases irritate the lungs and assist to increase respiratory infections. It is thought that most lungs damage occurred by PM_{10} and this exposure could also affect the health of mother, for example, PM_{10} may weak mother immune system and hence affect the fetus (Currie & Neidell, 2004).

The number of people suffering from hypersensitivity increased successively during the last century. Pollution in the environment contributes to some extent to inducing asthma, allergies and other hypersensitivity, but most importantly it maintains disorders in those who are already ill (WHO, 2004). Air pollution is also associated with the increase in numbers of people suffering from cardiovascular disease. Cancer diseases continue to increase. For exposure to radon, environmental tobacco smoke and air pollution the relation to lung cancer is proven. The connection between UV rays and skin cancer is also considered proven.

Community noise is a widespread environmental problem. Transport (motor vehicles, railway, airport, construction works and neighbors) are the main sources of community noise. Noise pollutions generate annoyance, sleep disturbance, hearing problems, stress and adverse effects on cognition. Cardiovascular diseases, blood pressure are also associated with exposure to the noise pollution (WHO, 2004). For example, in Sweden it is evident that about 1 million people suffer from noise in their place of residence at least once per week; more than 2 million are estimated in 1998 to be exposed to traffic noise above the outside of their house (Environment health Report, 2001). Although these types of noise may not create any serious illness, but may affects human well being negatively and reduce quality of life (Navrud, 2002).

In all over the world, health systems in different countries are seeking for efficiency (Polder et al, 2005). Cost-of-illness (COI) studies are valuable instruments for promoting awareness towards particular illnesses and conditions. Such information can help to determine research and funding priorities and can contribute to the efficiency debate by suggesting areas where inefficiencies may exist and savings could be made (Rice, 1994; Ament & Evers, 1993). Moreover, a COI study is also interesting primarily for making comparisons over time within a country and across countries. Notice that, COI studies make points of reference for economic analyses, but are not economic evaluations in themselves. Because COI studies are not concerning with specific health care interventions but estimate the economic burden that a disease places upon society. Even so, COI studies are not out of criticisms. There exist several arguments against undertaking and using the results of COI studies. A weak theoretical basis and lack of evaluation of the outcomes of different interventions are other arguments against COI studies (Henriksson 2001). Moreover, employing different types of data and methods in different COI studies, it may also difficult to compare the findings across the studies. However, COI studies that clearly document all assumptions and minimize the potential caveats with sound methodology, these studies may provide valuable information regarding the economic burden associated with a disease (Finkelstein & Corso, 2003). When COI studies are detailed and specify who pays for what, the distribution of resource utilization across healthcare sectors and populations can be identified then COI studies may provide a bench-mark for further research.

1.1 Aim

The aim of this essay is to provide a systematic review of the evidence of societal cost associated with air and noise pollution related ill-health. To identify the cost components and to know how air and noise pollution induce cost to the society, a general standard methodology of COI is provided. The difficulties in measurement and sources of data in estimating COI of air and noise pollution related ill health is also discussed. Finally, we summarize our findings and discuss problems in general in the reviewed studies and provide some suggestions for future COI studies on air and noise pollution.

1.2 Outline of the Paper

The paper is organized as follows. Section 2 describes the general methodological issues associated with estimating the COI with special focus on the methods for COI associated with air and noise pollution related morbidity and mortality. Section 3 illustrates the review methods. The findings of the review are provided in Section 4. The final section ends with a discussion, and some key conclusions and suggestions for future research.

2. COST-OF-ILLNESS: SOME METHODOLOGICAL ASPECTS FOCUSED ON AIR AND NOISE POLLUTION RELATED ILLNESS

Cost of illness (COI) try to estimate the economic burden of a disease on the society without examining clinical outcomes of different health care interventions. Cost studies can be either prevalence based or incidence based. The prevalence based approach is the more usual approach. Applying this approach estimate the total costs for a patient population in a given geographical area for a given period of time (Kobelt, 2002). On the other hand, incidence based studies measure life time cost of disease or phenomenon. Prevalence based studies is useful for planning and spending decisions. The main limitation of incidence based studies is that they require more time and resources but this approach is more appropriate when estimating the effect of certain interventions witch often makes an incidence based study the better choice (Kobelt, 2002). COI analysis can take different perspectives, e.g. societal perspective, patient perspective, ministry of health perspective etc. but the most frequently used perspective is the societal one.

COI studies are also performed as either “top-down” or “bottom-up”, depending on the data materials. Top-down studies use statistical databases and registers whereas bottom-up studies collect data directly from a patient sample and extrapolate this to the population. Both methods have some problems for a certain illness or phenomenon. For “top-down” cases, it is more common that all costs information may not available in such sources. Although in the “bottom-up” studies it is possible to capture most of the cost components and therefore are more preferable, however, these studies may also be problematic if the patient sample is not unbiased and not representative for the whole population.

Health impacts of air and noise pollution and its economic cost to society can be divided mainly into- direct, indirect and intangible costs. Direct cost include all type of resource use, such as private and non- private cost due to the diseases or its treatment (such as, the cost of medication, hospitalization, diagnosis, travel cost, waiting time cost at doctor's office, care givers time cost etc.). In addition, direct cost includes the cost of further test to follow-up and the future cost associated with the disease such as hospitalization and treatment cost. Indirect cost, also expressed as productivity cost that are related to loss of production due to morbidity or mortality caused by the disease/phenomenon. Intangible cost attach with the reduction of quality of life due to illness, such as pain and suffering, depression etc.

One may categorize four steps in estimating COI as Koblet (2002):

Step 1 is to identify the relevant resources that are used.

Step 2 is to quantify these resources in physical units (hospital bed days, no. of working lost etc).

Step 3 is to the value of resources used at their opportunity costs.

Step 4 is to do discounting resource use occurs at different points of time.

The valuation of resources (step three) in health care may be problematic for several reasons. "Micro-costing approach" includes the 'Bottom-up' approach where all relevant cost components are identified, measured and estimated for each individual patient (Kobelt 2002). However, it is often both difficult and expensive to acquire information with such level of details. Market price is the best instrument in valuing scarce resources (the opportunity cost of all resources that used for avoiding or get-rid off illness) under the condition of perfect competition. However, it may be problematic if there is imperfection in market. Another problem is that market prices in health care do not always play a good representative of opportunity cost. To overcome this problem, money prices require adjustments for inflation and adjustments are also needed for other kinds of market imperfections. In particular, when the data on prices come from different time periods, market prices can vary because of general inflation. The usual approach for handling price changes is to convert prices into a base year term.

To estimate the societal cost of air and noise pollution, it is also important to make comparison between the actual air and noise pollution level and some hypothetical level (e.g. no air and noise pollution situation in our case) of pollution known as counterfactual situation (Collins et al, 2005). This counterfactual situation may not possible to visualize because previous level of pollution or illness may affect present illness. For example, a person who was working in a construction firm and currently has been suffering from asthma which might strongly related to his past work environment. Therefore, for this particular situation, COI associated with asthma are unavoidable costs. “Avoidable costs are those costs which are amenable to public policies initiatives and behavioral changes” (Single et al, 2003). Therefore avoidable cost estimates may give a signal of the potential benefits available to the society as a consequence of investing public resources to the prevention or reduction of health hazardous activities (Collins et al, 2005), in our case, reduction of air and noise pollution. It is evident that avoidable costs always lower than the health damage costs (Sriastava & Kumar, 2001).

2.1 Direct cost estimation

To estimate the direct cost of air/noise pollution, one may use the following formulation in particular cost component. For instance, COI associated with hospitalization/physician consultation due pollution related diseases can be estimated as [this equation is taken from (modified form) the Report of Hong Kong Environmental Protection Department, 1998]:

$COI_{(hos)} = b(d_j) * E(d_j) * \{ RR(p_i, d_j) -1 \}$

where,

$COI_{(hos)}$ = economic cost of morbidity by hospital admission

$b(d_j)$ = actual hospital admission and out-patient doctor consultation due to a particular disease d_j

d_j = diseases (e.g., respiratory or cardiovascular diseases)

E = estimated cost related to hospital admissions and out-patient treatment for all cases due to d_j

RR = relative risk for morbidity - p_i, d_j (air/noise pollutant & disease specific in respective order)

p_i= air/noise pollutants (e.g. NO2, CO, PM_{10}, O_3 dB(A))

2.2 Indirect cost estimation

Indirect costs relate to production loss due to morbidly and mortality. Related indirect costs are:

a) Costs associated with unable to work or to engage in leisure activities (early retirement due to illness).
b) Production loss due to premature death.
c) Loss of production in the household sector (including voluntary work or informal care).

There are several alternative methods to estimate lost productivity (forgone income) at market price due to morbidity and mortality. The Human Capital Approach (HCA) is the most common way to estimate productivity losses. In the HCA for the estimation of productivity losses associated with the illness are measured by imputing the income foregone due to morbidity and mortality. In the case of mortality due to specific disease forgone income is estimated by calculated the capitalized value of future lifetime earnings that would have been earned by those who died prematurely. Average annual wage sometimes use to estimate the annual productivity of an average healthy working age person and annual productivity is adjusted downward to obtain "net annual productivity," which is the annual productivity minus the amount consumed by the worker. Imputing the Gross National Product (GNP) per capita is another option to estimate economic loss due to death[1]. In the case of morbidity, the production losses of morbidity are the value of workdays for each person who suffers from related disease. To evaluate the present value of the lost income, future earnings should also be discounted.

Productivity losses may also associated with non-market activities such as due to loss of time for caring disabled or sick people (informal care). These non-market activities occupy an important component in determining total economic costs of ill-health. In COI studies one should take into account the non-market activities e.g. loss of time as unpaid services borne by family members and volunteers. There are two alternative approach of valuing time in the literature. One is the 'opportunity cost approach' and the other is the 'market value approach' also called the replacement cost approach (Islam et al, 2001).

The Willingness-to-pay (WTP) approach, also known as "contingent valuation" usually used to value non-market attributes and primarily use in environmental economics. Presently the method also often employ in health economics. The WTP approach attempts to estimate what the

[1] For simplicity it is also assume that all lives in the country are of equal value.

individual or the household is WTP or would like to pay to prevent or avoid the disease. If it were attainable to elicit a dollar value that the individual/household would pay to prevent the disease, it would apparently reflect the opportunity costs to the individual/household's direct and non-direct health care cost and lost productivity as well as the value of the leisure time given up and the cost of the pain and suffering associated with the disease, and other intangible costs which are difficult to quantify in monetary value. However, when asking for the WTP, for example, noise reduction, one would normally get an answer that includes the valuation of the individual's actual income loss (not the total production loss in societal context) plus the value of pain and sufferings and other intangibles

There is another approach to quantify indirect cost known as the friction cost method that is presented by M. Koopmanschap (1995). The friction cost method assesses the difference between actual and predetermined employment level (Drummond et al 1997). This approach is carried by the idea that every firm try to restore their initial production level. If a worker gets ill (or unable to work), then employer try to replace another worker and it takes some time. The 'difference' or 'friction' is then considered as a cost. The valuation of friction period depends on workers sickness time length, age, sex and education levels. The friction costs are restricted to the short-term consequences of disease. After completion of the friction period, no costs are considered. This friction period is likely to differ by location, industry, firm and category of worker. This approach rather under estimates of production lost (production lost much lower) than traditional methods (Koopmanschap et al, 1995).

2.3 Intangible cost estimation

Intangible costs are related to reduction of quality of life and difficult to measure but there are some instruments that can be used, e.g. and the standardized EQ-5D questionnaire. The EQ-5D questionnaires give a utility value between 0.0 (dead) and 1.0 (perfect health) based on five attributes: mobility, self care, usual activity, pain/discomfort and anxiety /depression (Drummond et al, 1997). The number of quality adjusted life years (QALYs) lost due to a specific disease can be calculated by comparing the difference in utility between a sample with the disease and the general population for different age groups. However, if one does a conventional COI, yet using the EQ-5D is not sufficient as one still needs the valuation in monetary terms. In order to estimate intangible cost associated with illness a monetary value can be imputed for each QALY lost (Henriksson, 2001).

3. METHODS

3.1 Search strategy and inclusion criteria

The methodology used a systematic search on electronic databases for published literature. A detailed search of the databases is conducted for articles published between 1984 and the end of September, 2005. MEDLINE (via Pub Med), EconLit, and International Bibliography of the Social Sciences (IBSS) (via CSA) data bases are used for published papers. The sites of international institutions namely the World Bank and WHO, are used as additional sources of literature. Published studies perhaps so limited in the field of COI due to air and noise pollution related ill-health, therefore, further manual searches also used for unpublished literatures[2].

[2] Environment Protection Agency (USA), Ontario Medical Association (OMA) are two sources for such unpublished studies.

This review used the following key words: “air pollution” AND “noise pollution” OR “cost of illness” OR “economic costs” OR “economic effects”. Studies are published in languages other than English, are excluded from these analyses. We mainly include those studies that use a quantitative methodology and published in a peer reviewed journal.

3.2 Analytical strategies

We first divide the included studies according to county, where studies are conducted. Since the included studies for this review come from different countries with diverse economics, social and demographic context and consequently it is rather difficult to separate or grouping the studies according to the origin. However, for simplicity, we separate the studies whether they are conducted within OECD countries or otherwise. Our assumption is that some meaningful comparison may be worthwhile according to this criterion. Within this categorization, we further segregate the studies according to the publication status- whether published in peer-reviewed journal or not.

To review the included studies, this essay also splits every study in three main parts and analyzes accordingly. Firstly, we summarize the study characteristics focusing such as, the study perspective, type of analysis, data sources, sample size, whether top-down/bottom-up approach is followed. These characteristics of the studies are summarized in Table 2. Secondly, we also summarized the studies emphasizing methodological characteristics that are followed in estimating the cost of illness due to air/noise pollution related illness. For doing so, we identify the air/noise pollutants, cost components are considered in the paper. We also explicitly illustrate the estimation methods that apply in estimation of different cost components. Since productivity losses estimation seems to be critical, a special focus is also given on productivity loss estimation methods considered in different studies. This methodological review is described in table 3. Finally, in table 4 illustrates the summary of estimated total societal costs and its cost components in details. All costs are converted into a common currency (i.e. US dollar) and also presented per capita basis.

4. RESULTS

4. 1 Search Results

In total, over 28 articles are initially identified as potentially fitting the selection criteria (14 from PubMed, 9 from EconLit & IBSS and the rest 5 from the WB). From the initial searches, articles are excluded where the title and abstract made it clear that the paper do not fulfill the inclusion criteria. Collectively, these search strategies resulted in a total of 13 articles from 12 different countries fitting the study inclusion criteria. All studies are related with air pollution. We do not find any COI study on noise pollution.

Table 1: Total hits presented by database

Database	Number of Hits	Comments
EconLit and IBSS (via CSA)	13	9 relevant studies found
MEDLINE (via PubMed)	49	14 relevant studies found
The World Bank	08	1 relevant study found
WHO	109	No relevant study found

As seen in table 2-4, in our included studies out of the 12 studies, 8 studies are published and the rest 4 studies are unpublished. For 5 studies data come from OECD countries of which 2 are unpublished studies. 7 studies use conducted in non-OECD countries of which 5 are published and 2 are unpublished studies.

4.2 Study Based on the OECD Countries

4.21 The Published Studies

Zmirou et al. (1999)

The main objective of this paper is to provide estimates of societal cost due to air pollution in urban area of Western Europe and to discuss the primary causes of uncertainty those bear on these estimates. The study based on a cross-sectional data and data come from three metropolitan areas of the Rhone-Alpes region in France in 1994. Information is gathered on particulate air pollution and the occurrence of respiratory conditions in random samples of the general population (total number of inhabitants 970,000). A prevalence based approach is used to estimate COI due to particulate air pollution (PM_{10}) induced diseases.

To calculate the societal cost, this study estimates direct health care costs (Doctor's fees, other health professionals' care costs, such as physiotherapists costs, drug consumption costs, hospitalization costs) and indirect costs (wage losses due to absenteeism). This study use human capital approach for estimating productivity losses. It is reported that the over-the counter drug consumption represents the largest cost component of direct costs (approximately 44% of total costs). One the other hand, hospitalization costs amount to a lower percentage of total costs (about 5%) because most respiratory disorders do not require hospital care. Cost due to mortality is not considered in this study. The total cost of three selected cities of France is estimated as 214 million France francs. To notice the effect of statistical variability (sensitivity), the ranges of cost estimates also incorporate in this study.

It seems that Zmirou and his colleagues estimate most of the cost components in estimating societal cost associated air pollution except intangible costs. However, this study do not estimate cost due to mortality which makes the study an incomplete COI study.

Voorhees at al (2000)

In the context of Japan, using environmental, political, demographic, and medical data from 1973 to 1994, Voorhees at al, attempt to estimate the COI due to air pollution (nitrogen dioxide) and also attempt to evaluate the economic effectiveness of NO2 control polices in Tokyo.

To estimate the societal cost, this study is estimated the direct costs of medical expenses, non-direct medical costs (mother's wages loss due to caring their sick children) as well as estimate the cost of productivity loss due to air pollution related diseases. To quantify productivity loss, this study use Tokyo's average wage and average duration of pollution related illness, the net cost of lost wages in workers.

Imputing Tokyo's average medical cost of pollution related illness, the study tries to estimate the net direct medical cost for adults due to incidence of phlegm and sputum and find the cost is around $6.08 billion and also reports the net medical costs of children due to incidence of lower respiratory illness is about $775 million. The study also estimate one important cost component - the mother's caring costs for their sick children and find the cost is about $833 million. The paper estimate productivity cost is $6.33 billion. This study also conducted sensitivity analyses for their approximations and reports the upper and lower limits. Further, based on their Benefit-cost analysis, the study concludes that Tokyo's NO2 control policies are economically quite effective.

It appears that Voorhees at al estimate most of the cost components and most importantly the study considers mother's caring costs for their sick children in estimating societal cost associated air pollution, however, as usual not estimate intangible costs associated with diseases. Moreover, the authors also do not estimate mortality cost.

Neidell (2004)

In a recent American study, Neidell (2004) reports that carbon monoxide (CO) has a significant health impact among children. Although this study is not a direct cost-of-illness (COI) study but using California Hospital Discharge Data (CHDD) from 1992 to 1998 the author attempt to assesses the hospitalizations cost associated with childhood asthma among children under age 18 in California (in 1998). The author also shows that the decline in pollution levels from 1992 to 1998 decreased asthma rates by between 5% and 14% and also saves approximately $5.2 million for asthma admissions in California in 1998. To obtain this result, the study multiply total number of hospital admissions into the average cost of hospitalization. A second finding is that the avoidance behaviour appears to play a significant role in reducing the effect of pollution on childhood asthma, as indicated by the negative effect of smog alerts on admissions. The third finding is that the net effect of pollution is greater for children of lower socio-economic status (SES).

To estimate the societal cost this study estimates only one component of direct cost (hospitalization cost) but do not estimate care giver costs, follow-up treatment, lost wages of family, or other non direct health care costs and cost due to productivity losses. Moreover, the study only considers asthma related illness but not mortality due to asthma. This study also ignores intangible costs (pain, discomfort, anxiety, psychic costs etc.) associated with illness.

4.22 The Unpublished Studies

DSS Management Consultants Inc (2000): Ontario Medical Association (OMA) Study

The report is commissioned by the Ontario Medical Association, Canada. The study attempts to estimate COI due to air pollution by a group of people with diverse backgrounds under the support of DSS Management Consultants Inc., a consulting firm. Employing extensive socio-demographic and environmental secondary information come from Statistics Canada & Census Information for the year 2000, the report forecast that by 2015 approximately 1,900 premature deaths, 9,800 hospital admissions, 13,000 emergency room visits and 47 million minor illness days are expected to occur in Ontario as a result of air pollution. The study is a prevalence based analysis applied for PM_{10} and Ozone related health problems.

To estimate total societal cost related with this environmental hazard, the report seems cover almost all cost components of societal costs due to air pollution i.e. direct, indirect and intangible cost. To estimate direct cost the study considers the components, such as hospital admission, emergency room visit. To calculate indirect cost the report estimates both costs associated with lost productivity and absenteeism in work place and also estimated productivity losses due to premature deaths. The cost of pain and suffering due to illness also estimated as intangible cost. To quantify productivity losses due to air pollution the study employs the Human Capital Approach for both economic loss due to morbidity and mortality. The annual time lost due to illness is estimated by the expected number of cases by the lost time per case. To generate related economic damages, the number of lost days is multiplied by the value of a lost working day.

The direct health cost is estimated as a total of about $600 million that costs to the health care system and another $560 million cost is estimated for direct losses to employers and employees due to productivity losses. The monetary value of pain and suffering is projected as $5 billion and the productivity loss due to loss of life is estimated as $4 billion. In total, the report estimates health impact due to air pollution related illness and mortality is about $10 billion (approximately) in 2000. The study, however, do not employ any sensitivity analysis about the estimates.

Vergana and the Mexico Air Quality management Team of the WB study (2002)

Commissioned by the World Bank, The Mexico Air Quality Management Team (under the Third Air Quality Program 2001-2010) conducted a study named as- 'Improving Air Quality in Metropolitan Mexico City'. The study gather relevant information from, different sources, e.g. to know the average pollution exposures for individuals, air pollution data are gathered from local monitoring stations and demographic information is obtained from Mexican National Institute of Statistics. This study focuses on the two important economic impacts of air pollution, namely health impacts and restrictions imposed on economic activities through environmental contingencies.

To estimate the societal cost, this study estimates the direct cost of hospitalization and cost for emergency room visits and mother's working days loss due to RAD in children (direct non health care cost). The human capital approach is used for valuing the lost of productivity associated with morbidity and mortality. To quantify the number of years of life lost (YOLL), this study take on average 0.75 years of life lost per case and 3% discount rate has been used. A prevalence based study applied and sensitivity analysis also conducted in estimating costs range (i.e. high, central, low). According to the central estimates, the study reports that the annual benefits of a 10% reduction of PM_{10} and Ozone level (from current level) is approximately $760 million in 1999. The high and low estimates of the values are $1607 million and $154 million respectively.

Table 2: Summary of study characteristics

Study	Country	Study Year	Data Source(s)	No. of Observations	Perspective	Incidence\ Prevalence	Top-down\ Bottom-up	Sensitivity Analysis
Published Studies : OECD Countries								
Zmirou et al, 1999	France	1994	Primary data A Cross- sectional study conducted in the three cities in France	970,000	Societal	Prevalence	Bottom-up	Yes (Low and High)
Voorhees et al, 2000	Tokyo, Japan	1973-1994	Secondary sources	Not stated	Societal	Prevalence	Top-down	Yes
Neidell, 2004	California, USA	1998	Secondary source California Hospital Discharge Data(CHDD)	800,000 (Children ages 1-18)	Societal	Prevalence	Top-down	Yes (Low and High)
Unpublished Studies : OECD Countries								
Report of Ontario Medical association (OMA), 'The illness costs of air pollution in Ontario', 2000	Canada	2000-2015	Statistics of Canada & Census Information	11 million (total population of Ontario)	Societal	Prevalence	Bottom-up	No
Mexico Air Quality Management Team , 2002	Metropolitan Mexico City (ZMV)	1999	Secondary sources: Mexican National Institute of Statistics, Geography & Information (INEGI) National Health Survey,1994	17 million	Societal	Prevalence	Bottom-up	Yes
Published Studies : non-OECD Countries								
Larson et al, 1999	Volgograd Russia	1995	Secondary data 29 stationary sources	Total population 50,000* 29 =1,450,000	Societal	prevalence	Bottom-up	Yes
Alberini & Krupnick, 2000	Taiwan	1991-1992	Primary data	Total population 3,031,532 Sample observations =87,676	Societal	Prevalence	Top-down	No

Srivastava & Kumar, 2001	Mumbai, India	1997	Sources: Institute for Population Sciences, Mumbai, Transport Commissioners office, Maharashtra State, Mumbai.	15.6 million	Societal	prevalence	Bottom-up	No
Quah & Boon, 2003	Singapore	1999	Secondary data ENV Annual Report,1998; Monthly Digest of Statistics,1999; Singapore Dept. of Statistics; Ministry of health, Singapore.	Total population in Singapore= 3,893,600	Societal	Prevalence	Top-down	Yes(High, central& Low)
Resosudarmo & Napitupulu, 2004	Indonesia, Jakarta	1998	Indonesian Central Statistics Body(BPS)	Total population in Jakarta =11 million	Societal	Prevalence	Bottom-Up	No
Unpublished Studies : non-OECD Countries								
Saksena & Dayal, 1997	India	1997	Secondary Sources Central Pollution Control Board (CPCB), Central Bureau of Health Intelligence (CBHI).	Total population in India= 846 million (used 1991 census)	Societal	Prevalence	Bottom-up	Yes(Low &High)
Report of Environment protection Department, Hong Kong, 1998	Hong Kong, China	1997-1998	Sources: Report on Focus Group Survey Data, hospital Authority (HA), Department of Health, Census & statistics Department & Government Gazette.	Total population in Hong Kong = 6.31million (estimated in 1996)	Societal	Prevalence	Bottom-up	Yes (ranging numerical)

Note: Only abstract has been found for the study conducted by Voorhees et al (2000).

Table 3: Summary of study (emphasizing methodological characteristics)

Study	Components of Air Pollution	Mortality & Morbidity (Types of Diseases)	Cost Components and Estimation method	Approach(s) used for estimating productivity Losses	Discount rate
			Published Studies : OECD Countries		
Zmirou et al , 1999	PM_{10}	Morbidity :Asthma & other respiratory conditions or symptoms	Direct medical costs: drug consumption, medical and other health professionals' care, biological or radiological examinations, daily hospital costs. Indirect costs: Work absences due to illness (adult males), Work absences for child care (mothers), Days of school absences. (Wage losses converted into average daily wage losses) Method: This study multiplies 970,000 inhabitants (three cities of France) into average unit cost of asthma & other respiratory conditions.	VOSL estimates by HCA.	Not stated
Voorhees et al , 2000	Nitrogen dioxide (NO2)	Morbidity: Phlegm & Sputum in adults, Lower respiratory illness in children.	Direct costs: Direct medical costs. Indirect costs: Costs of lost wages in workers & costs of wage losses in mothers caring for their sick children. Method: Average cost into population.	Not found	Not found
Neidell , 2003	Carbon monoxide(CO)	Morbidity: Asthma (children)	Direct costs: Hospitalization costs. Method: Costs=average charge in ER admission for asthma* number of admissions.	N/A	Not stated
			Unpublished Studies : OECD Countries		
Report of Ontario Medical association(OMA), 'The illness costs of air pollution in Ontario, 2000	Ozone &PM_{10}	Respiratory& Cardiovascular illness	Direct costs: Morbidity: Hospital admission, Emergency room visits costs, Doctor's room visit costs, Medication costs & mortality costs. Indirect costs: Lost productivity. Intangible costs: value of pain & suffering. Method:	VOSL estimates by HCA	

Mexico Air Quality Management Team , 2002	PM_{10} & Ozone	Mortality. Morbidity: Respiratory diseases (Cardiocerebrovascular, Congestive heart failure) Asthma Chronic morbidity: Chronic bronchitis &chronic cough, prevalence (children).	Direct costs: Medication cost, Hospital admission, Emergency room visits. Indirect costs: Restricted activity days work days loss(adult) Work days loss for women due to RAD in children Method:	Years of Life Lost (YOLL) using HCA	3%
Published Studies : Non-OECD Countries					
Larson et al , 1998	PM_{10}	Mortality risks.	Direct costs of mortality. Method: Volgogard represents a population of 50,000 people and annual numbers of deaths are estimated as 2666.88. Total costs of mortality = annual mortality costs multiply by total population.	VOSL estimates by HCA	10%
Alberini & Krupnick, 2000	PM_{10}	Morbidity: 19 minor respiratory-related symptoms, Such as cold, sore throat, headache, eye irritation etc.	Direct health care cost: namely: doctor's fees, prescription medication cost. Indirect health care cost: earning loss. Method: to estimate the cost of illness, this study multiplies the average residents of three Taiwan's cities into doctor's visits. Medication costs, and earning lost	Lost earning converted into per work days loss, Estimates using HCA (WPA also)	Not stated
Srivastava & Kumar, 2001	NO_2 , CO, HC, PM (below 10 Micron)	Mortality and Morbidity: Chronic bronchitis, Bronchitis in children, Asthma, Respiratory symptom& illness.	Direct costs: Emergency room visits, hospital admission. Indirect costs : Loss of salary, Restricted activity days Method: average income loss due to morbidity & mortality multiply with total population	VSL estimates by using HCA(WP also)	5%
Quah & Boon, 2003	PM_{10}	Mortality. Morbidity: Asthma Respiratory Symptoms -Lower Respiratory Illness in Children (LRI) -Chronic bronchitis.	Direct costs for morbidity: Emergency Doctor's room visits, Hospital admission, Direct cost of premature mortality. Indirect costs: Restricted activity days Method: VSL multiply by total number of death due to pollution.	VOSL estimates by using HCA (WP also).	3%

Resosudarmo & Napitupulu, 2004	PM_{10}, $NO_{2,}$ SO_2	Premature mortality. Morbidity: Asthma attacks, chronic bronchitis, respiratory symptoms in children, chest discomfort in adults.	Direct costs: Hospital admission, emergency room visits. Indirect costs: Cost of premature death & restricted activity days. Method: To estimate the direct cost, this study use average cost for per case.	VOSL using by HCA	5%
Unpublished Studies : Non-OECD Countries					
Saksena & Dayal , 1997	PM_{10}	Premature death. Morbidity: Respiratory symptoms Lower respiratory illness Asthma Chronic bronchitis	Direct costs: Hospital admission, Emergency Doctor's room visits. Indirect costs: Restricted activity days. Method: Costs= total population multiply by the unit values of health damage.	VOSL estimates by using HCA	5%
Report of Environment Protection Department, Hong Kong, 1998	$NO_{2,}$ $SO_{2,}$ Rsp, & Ozone ($O_{3)}$	Mortality & Morbidity: Respiratory diseases, Cardiovascular diseases	Direct costs : Self medication& any other related expenses, Hospital admissions, Consultation fees (public+ private), Registration charge. Indirect costs: Wage loss due to illness. Method: TC=VSL multiply by total number of illness associated with air pollutants.	VOSL estimates by using HCA (WP also).	7%

Table 4: Summary of Total Cost by Cost Components

Study	Cost Components				Total Societal Cost	Per Capita Cost	COI as % of GDP
	Direct Health care	**Direct non-health care**	**Productivity Losses**	**Intangible Costs**			
Published Studies : OECD Countries							
Zmirou et al , 1999	US $ 6.60 million to $ 11.25 million (1 French francs=$0.17 in 1994)	Not estimated	$ 5.10 to 8.72 million	Not estimated	US $ 13.43 million to US $ 22.95 million 1 French francs=$0.17 in 1994)	US $13.85 to US $23.66	Not stated
Voorhees et al , 2000	US $ 6,860 million	US $833 million	US $ 6,330 million	Not estimated	US $14,023 million	N/A	Not stated
Neidell, 2003	US $5.2 million	Not estimated	Not estimated	Not estimated	US $5.2 million	US $ 6.5	Not stated
Unpublished Studies : OECD Countries							
Report f Ontario Medical association (OMA), 'The illness costs of air pollution in Ontario', 2000.	US $674 million (approx) Can $1= US $ 0.674	Not estimated	US $ 2,696 million (approx)	US $3,370 million (approx)	US $ 6,740 million (approximately)	US $ 612.73	Not stated
Mexico Air Quality Management Team, 2002.	Direct costs average are estimated by service per case and disease specific basis: Hospital: $1,870-$5,611 Emergency room: $91	Not estimated	Average daily wage loss for adults = $9.52 (in 1999 US. dollars)	Not estimated	US $760 million (approx) (in 1999 US. dollars).	US $ 44.71	Not stated

Published Studies : Non-OECD Countries							
Larson et al , 1998	US $28.8 million to 80.01 million (in1997 US dollars)	Not estimated	Not estimated	Not estimated	US $28.8 million to US $ 80.01 million (in1997 US dollars)	US $19.86 to US $ 55.18	Not stated
Alberini & Krupnick , 2000	US $510,491 ($PM_{10}$ =100 mg/m^3) toUS $ 804,298 (PM_{10} =350 mg/m^3) (in1992 US dollars)	Not estimated	US $117,575 to US $244,477 (in1992 US dollars)	Not estimated	US $ 628,074 to US $ 1,048,775 (in1992 US dollars)	US $0.21 to US $0.35	Not stated
Srivastava & Kumar, 2001	US $ 232.34 million (in 1997 US dollars) 1 Indian Rs =US$ 0.0275	Not estimated	US $76.32 million 1 Indian Rs =US$ 0.0275	Not estimated	US $ 308.66 million 1 Indian Rs =US$ 0.0275	US $ 19.79	Not stated
Quah & Boon, 2003	US $1,773 million (for mortality) US $1,889 million (for morbidity). (in1992 US dollars)	Not estimated	Not estimated	Not estimated	US $3662 million (in1992 US dollars)	US $ 940	4.31%
Resosudarmo& Napitupulu, 2004	US $180 million dollars (approximately) (in 1998 US dollars)	Not estimated	Not estimated	Not estimated	US $180 million dollars (in 1998 US dollars, approximate)	US $ 16.36	1%
Unpublished Studies : Non-OECD Countries							
Saksena & Dayal , 1997	US $ 1,99.11 million (in 1995 US dollar) 1 Indian Rs = US $ 0.0253	Not estimated	US $ 18,783.99 million (in 1995 US dollar)	Not estimated	US $ 18,983.10 million (in 1995 US dollar) .	Lower estimates: US $2,000 for female and US $1,400 for male	Not stated
Report of Environment Department, Hong Kong, 1998	US $ 33.02 million to US $ 57.79 million (in 1998 US dollar) 1HK $ = US $ 0.129	Not estimated	US $ 437.66 to US $462.43 million (in 1998 US dollar) 1HK $ = US $ 0.129	Not estimated	US $ 495.45 million (approximately) (in 1998 US dollar) 1HK $ = US $ 0.129	US $ 78.52	0.35%

4.3 Study Based on Non-OECD Countries

4.31 The Published Studies

Larson et al (1999)

The main aim of this study is to estimate health risk due to direct particulate emissions form 29 stationary source polluters in the city of Volgograd, Russia. To evaluate the risk reduction options that have been identified for the major particulate emitters in Volgograd, cost-effectiveness and benefit-cost analysis of different emission reduction projects are also conducted

The study estimates that annual particulate-related mortality risks is the range of 960 and 2,667 additional deaths per year in this city with one million inhabitants. To quantify productivity losses due to these additional mortality, the study use the human capital approach. Using a simple benefits transfer approach for estimating value of statistical life (VOSL) in the USA, this paper applies same methodology for calculating a VOSL in Russia and adjusted this value using GNP per capita for Russia. To transfer the USA GNP per capita to the Russian context, they consider that Russian GNP per capita is about 18% or one-fifth less of the USA's GNP per capita on a purchasing power party basis (World Bank, 1996). The lower bound estimate of the VOSL in Russian is estimated about $30,000. 10% discount rate has been used to estimate the present value of productivity losses due to mortality. Considering the uncertainty in the estimates the study reports total mortality cost for this city is ranged between $28.8 million to $80.01 million. In conducting benefit-cost analysis, the study also reports that the marginal cost of mortality risk reduction for six pollution abatement investment projects, the lowest cost option is in the range of $75-$340 and the highest cost option to a range about $6800-$31,200. The study does not consider different type of morbidities associated particulate emissions, however, authors acknowledge that they would increase total cost of health risk due to particulate emissions and increase the benefits of particulate reductions.

Alberini and Krupnick (2000)

The study attempts to compare COI-based estimate and WTP-based estimates of the health damages (19 minor respiratory-related symptoms) associated with air pollution (PM_{10}) for the respondents of the former Republic of China (Taiwan). The authors conduct a combined epidemiological study and economic study in three cities of Taiwan in 1991 and 1992. To estimate both COI and WTP, a prevalence based approach is used in the study and employing both epidemiological and economic information. The epidemiological part consists a prospective cohort study where information are gathered about minor respiratory symptoms and economic study includes a contingent valuation survey in three urban cities of Taiwan with varying air quality levels in 1991-92.

To estimate the societal cost, authors divides total costs into direct health care costs and cost due to productivity losses. They mainly include two main direct cost components, such as cost incurs for doctor's visits and medication costs. The study also estimates these cost components considering different level of particular matters, i.e. for different level of PM_{10} intensity. To quantify productivity losses due to morbidity they use average income and discounting future income. The study uses simple adjustment of transferring benefits for the income differential between the USA and Taiwan.

According to the study estimates, total doctor's prescription cost is calculated about $250,000, $278,000 and $416,000 when particulate matter is 100 ug\m^3, 150ug/m^3 and 350 ug\m^3 respectively. Productivity losses due to illness are estimated approximately $117,000 at 100 ug\ m3 and about $245,000 at 350 ug\m$^{3.}$ All cost estimates are in 1992 U.S. dollars. The study reports that the WTP estimates are greater than the COI estimates and exceeding the latter by 1.61 to 2.26 times, depending on the pollution levels.

The study considers only one air pollutant, however, as one may recognize there are other potential air pollutants that could also causes health damages and generates economic cost for the individuals. Secondly, other than cost from morbidity, the study does not estimate other costs, particularly, intangible cost due to illness and cost related with premature mortality.

Srivastava and Kumar (2001)

Using data from National Environment Engineering Research Institute (NEERI) and Brihanmumbai Municipal Corporation (BMC) a recent study conducted by Srivastava and Kumar in Indian context. The aims of this paper are to estimate the air pollution loads and to estimate the morbidity and mortality cost in Mumbai city caused mainly by automobiles and domestic sources. To achieve the objectives the authors estimate daily exposure of an individual (how many time spent of an individual in different microenvironments during one day). This paper also estimates avoidance costs by adopting pollution control methods for vehicles and avoidance costs for emission due to cooking. Employing secondary data from different sources for the estimation of cost components, a prevalence based COI exercise applied for specific air pollution related diseases (chronic bronchitis, asthma, respiratory symptom& illness and death).

To estimate the societal cost, the study divides costs into direct and indirect health care costs. Direct health care cost consists of cost due to emergency room visits and hospital admission. The indirect health care costs divide into salary loss and restricted activity days. Restricted activity days have been valued as 20% work loss and 80% lower productivity. Productivity losses are estimated by considering average wage in Mumbai which is valued as Rs.80 per day and lower productivity is valued as one third of average wage and is approximated to be Rs. 37.50. To estimate the value of statistical life (VOSL) the study considers the discounted value of expected future income at the average age and 5% discount rate has been used for future income. This study follows Human Capital Approach for estimating productivity loss. The estimated total cost is 11224.17 Rupies per person in Mumbai, a selected city of India.

It seems that authors estimate most of the cost components in estimating societal cost associated air pollution but the study not estimate other direct and non-direct health care costs (e.g. doctor's fee, medication cost, travel costs, waiting time costs etc.) and intangible costs. Moreover, it seems that this study does not conduct any kind of sensitivity analysis.

Quah & Boon (2003)

The study attempts to estimate the economic costs associated with particulate air pollution related health damages in Singapore in 2002. To gather information on air pollution and to estimate total cost for different cost components, the study employs different proximate values for different parameters. To obtain the values for different parameters the study use secondary information that come form different sources (see table 2). The study adopts a prevalence based COI exercise applied for specific PM_{10} related health problems.

The authors calculate cost in terms of the statistical lives that could be saved and the morbidity cost related with air pollution. To estimate the societal cost the study divide total costs into direct health care costs and indirect (productivity loss) health care costs. Direct cost includes mortality and morbidity costs. The study use Human Capital Approach (HCA) for estimating productivity loss. The HCA used to measure the present and future production costs of pollution related deaths, occurring during the study period.

The study estimates total cost of health damage in Singapore is about US$3662 million which is about 4.31% of total GDP of the country. To ascertain that the results are robust (upper, central, lower), this study also conducts sensitivity analyses and concludes that the results do not vary significantly implies that the estimated values are robust.

Resosudarmo and Napitupulu (2004)

Using Indonesian Central statistics Body's (BPS) data, Resosudarmo and Napitupulu aim to estimate the health cost of Jakarta's air pollution in 1999. In 2001, the Indonesian government planned to a lunch program to control vehicle emissions, therefore, the paper also aims to estimate the economic impact of this program. To achieve this goal, this paper also evaluates the societal costs of air pollution in Jakarta for the year 2015 with and without the program.

To estimate the societal cost, this study considers only two components of direct health care costs namely hospital admission costs and emergency room visits costs. This paper employs human capital approach to estimate production loss and use value of statistical life (VOSL) for premature mortality. To estimate the present value of production losses due to morbidity and premature mortality, restricted activity days (per case of morbidity and mortality), the study use 5% discount rate for future income for an additional 38 years of life.

The total cost of health problems associated with air pollution is estimated approximately 1.7 trillion rupee (or $ 180 million) in 1998. This is approximately 1 percent of Jakarta's GDP.

4.32 The unpublished studies

<u>Saksena & Dayal (1997)</u>

In the Indian context, Saksena & Dayal attempt to estimate the incidence of mortality and morbidity on different groups (men, women, rural, urban etc.) due to particulate matter (PM_{10}), and converts these impacts into economic values. Another important aim of this paper is to estimate abatement costs in Delhi for key management options and also estimate the lower bound of the benefits of these key management options in Delhi.

To estimate the societal cost, this study include two direct health care cost components of hospital admission cost, emergency doctor's room visit. To quantify productivity losses, this study use human capital approach and consider unit cost for per case. To estimate the present value of productivity losses due to premature death and restricted activity days, authors use VOSL with 5% discount rate for future income for an additional 10 years of life. Sensitivity analysis is also conducted by estimating higher and lower boundary unit costs for per cases.

However, this study does not estimate other non direct health care costs (travel costs, waiting time cost at doctor's office etc.) and intangible costs.

<u>The Hong Kong Environmental Protection Department Study (1998)</u>

Using focus group survey data and other non survey data (the hospital authority, Dept. of health, Census and statistics department and government gazette), The Hong Kong Environmental Protection Department estimates the economic cost associated with air pollution related health effects. This study estimates COI associated both morbidly and mortality in Hong Kong that attributable to air pollution and also compare to willingness-to-pay (WTP).

The study calculates the direct cost of hospitalization and out-patient medical consultation, and indirect cost of loss of earnings and productivity. To estimate intangible cost, this study includes the cost of pain and suffering associated with disease occurrence as well. To quantify the cost of productivity loss, this paper uses human capital approach as well as WTP approach. To estimate the present value of production loss due to mortality, the author use Value of Statistical Life (VOSL) with 7% discount rate for future income for an additional 40 years of life.

According to their estimates the total cost of illness (i.e. mortality and morbidly) ranged from HK$9.7 million (for SO_2), HK $73 million (for NO_2), HK$28.36 (RSP), HK$49.64 (0_3) for every microgram per cubic meter increase in the concentration of the single air pollutant. Higher values are obtained when using the WTP approach, ranging from HK $16.7 million (for$SO_2$) to HK $105.1 million (for NO_2) for per cubic meter increase in concentration level of the pollutant. The total cost of mortality and morbidity due to air pollution is estimated as HK$ 3840.72 million which is the 0.35% of GDP of Hong Kong. A sensitivity analysis also conducted by estimating the range of cost. But this study does not include other non-direct health care costs such as travel time cost, waiting time at doctor's office, family member's leisure time etc.

4.3 Summary of Findings

Following the selection criteria, we have reviewed 12 studies on COI related with air pollution related ill-health that come from 12 different countries. No COI study is found on noise pollution related ill-health. In our review, it seems that out of the 12 studies, 6 studies have looked both mortality and morbidity effects of air pollution, 5 studies have considered only morbidity and 1 study has looked only mortality effects. All the studies except one

(Larson et al. 1998) have used some sort of disease classification. As air pollutants, a majority of the studies have looked the effect of PM_{10} (only one pollutant) on health. Most of the studies in the review have found that air pollutants are the main sources of respiratory and cardiovascular diseases and contribute to increase hypersensitivity (different kind of allergies, headache, eye irritation, cough, phlegm etc.).

Our review also reveals that both published and unpublished studies estimate most of the cost components associated with air pollution. Out of 12 studies, 10 studies looked both direct and indirect costs and only one study focuses direct, indirect, and intangible costs associated air pollution. Most of the studies have looked the cost of productivity losses due both mortality and morbidity.

All studies except one that has estimated non-direct health care costs in Tokyo (mother's work days lost for caring their sick children) and it's a huge amount about $833 million. Sometimes informal care is treated as a non-market activity because care giver's time normally classified as leisure time (Netten, 1993). Care giver's time cost or informal care's cost is an important component of non-direct health care costs.

It seems that a huge societal cost is concerned with air pollution related health hazards. For example, COI related with air pollutions is 3.4% of GDP in Singapore, 1% of GDP in Jakarta and US $13.43 million to US $ 22.95 million in France for a population of about 1 million.

As seen in Table 4, although we have tried to calculate COI per capita (in US dollar) for different counties, which ranged from US $6 to $613 in the OECD countries and US $0.20 to $2000 in the non-OECD countries. However, it is rather difficult to compare the monetary estimates of the reviewed studies and it is not directly within the scope of interest for this review. Different methods are used different countries and different included cost components are the obvious obstacles for comparison results. In particular, only one study in this review estimated an intangible cost, that's why it is very difficult to draw any conclusion about the intangible costs of air pollution related studies. Moreover, this review reveals that in estimating COI in different studies the sample sizes or total population varies considerably among the studies. In addition, is worth mentioning that the result of a COI study depends on a country's overall health care system, particularly on the institutional structure, such as the rules for sickness absenteeism, health care financing system etc.

5. DISCUSSION AND CONCLUSIONS

5.1 Discussion

The present paper conducts a systematic review that focuses on the total societal costs associated with economic burden of air and noise pollution related ill-health. About 50% of the included studies have looked both mortality and morbidity effects due to air pollution. All studies have estimated the substantial societal costs of particulate air pollution. It also appears that the reductions in the level of pollution do have the potential health benefits.

Our review reveals that in estimating COI in different studies the sample sizes varies considerably among the studies. Small sample sizes may lead to a selection bias and limits the possibilities of extrapolating COI results to national levels.

As air pollutants, a majority of the studies have looked the effect of PM_{10} (only one pollutant) on health. However, it is well documented that five criteria pollutants, namely, sulphur oxide (SO_2), carbon monoxide (CO), nitrogen dioxide(NO_2), particulate matter (especially PM_{10}

and $PM_{2.5}$) and ozone adversely affected human health. Some studies have also looked the bad effect of the only two or three pollutants on health. It is the case why many environment specialists believe that the true number of air pollution related health problems would underestimate.

Moreover, most of the studies use annual average level of air pollutant in their analysis, however, the pollution level actually fluctuates quite widely on an hourly basis. Studies also show that the peak level of air pollution estimated on the basis on several hours is much higher than the annual average level. Consequently, health impact of air pollution or societal cost would be different for how pollution level is estimated.

In estimating health impact of air pollutants most studies employ Dose-Response functions approach. The Dose-response function approach was mainly developed by Ostro (1984) and designed for doing epidemiological studies in the United States cities. After Ostro (1984), the same techniques have been applied in different countries (developed and developing) and settings for assessing the economic effects of air pollution on health. However, the applicability of this approach is context depended. This method could be rather sensitive in developing world because in many respect, particularly demographic composition, weather, per capita income and income discrimination (e.g. daily wage different for different income groups in India) and different welfare system. For example, Srivastava and Kumar (2001) have applied dose-response function for doing economic evaluation of air pollution on health in Mumbai city and use daily wage and average annual income in Mumbai. While in evaluating ill-health impacts, they have suggested to be considered different wages for different income groups as well as pollution exposures for different socio-economic groups within the society. If not, it would be possible to under or overestimate the number of health problems and the corresponding societal cost associated with air pollution.

Nevertheless, all includes studies in our review have focused only outdoor pollution but it is noticed that in terms of human person hours, 68% of all developed country person hours are spent indoors in urban environments and 21% are spent indoors in rural environments, leaving only 11% of time in the outdoor, whereas the proportions are 70% and 30% in the developing countries (Quah & Boon, 2003). Moreover, in the developing country, the most part of an individual’s time (especially women) is spent indoors. Women of developing countries are spent their most of the time for caring babies and cooking. Normally they use bio fuels (such as wood, dung cake etc.) for cooking and there is no ventilator in their kitchen (Saksena and Dayal, 1997). Consequently, most of the mothers and children (under age 5 year) in the rural area have been suffering respiratory symptoms illness or asthma. Although indoor air pollution affects health aversely but no single study addressed both outdoor and indoor air pollution problems simultaneously.

All studies except one (Neidell, 2004) that have looked the effect of outdoor air pollution on asthma for children age between 1 and 18 years. The important finding of this paper is that the net effect of pollution is larger for children of lower socio–economic status (SES). Notice that, neurobiological and economic research has suggested that early shocks to a child’s health can persist for many years (Shonkoff and Marshall, 1990; Case et al., 2002). Therefore, if poorer families are unable to afford to live in cleaner areas and consequently their children’s health development suffers. This would suggest that environmental pollution may one potential mechanism by which socio-economic status (SES) affects health.

It is also observed that all studies included in our review are prevalence based. This implies that the studies consider cost estimation that occurs during the study period but not estimated for life time costs due to air pollution related health hazards. Normally, incidence based studies can be used to predict future costs specially mortality costs due to illness which make them more useful for economic evaluation of certain health care interventions (Koopmanschap, 1998). There are some diseases (for example, asthma, cardiovascular diseases) are needs life time treatments until death that's why it is important to conduct incidence-based studies for future research.

Finally, most of the studies included in our review have further common methodological limitations. In particular, economists use the term "opportunity cost" or "economic cost" in conducting COI studies. Theoretically, the use of the opportunity cost approach can be seen as preferable to other approaches because it gives a true sense of the economic costs of the disease. However, measurement of the opportunity cost of an illness is not an easy task. One of the difficult issues is to estimate the lost of productivity loss due to illness. Employing HCA, GNP per capita or wage rate it is often pointed to that imperfections occur in the labor market. Therefore, a person's earnings may differ from the actual value of his/her output or productivity. In developing country context, where labour market in not so developed, wages may not be good measure in estimating productivity losses. It also argued that the HCA rather underestimates than over- estimates true productivity loss, because it values life using market price and thereby yields low values for the people outside the labour force, e.g. children or retired persons (Rice, 2000). According to HCA, there is another problem arise when an individual die after he retired. He/she does not contribute in production but needs to continuous consumption for survive his future life and this consumption could create some negative costs for society. Furthermore, costs due to pain and suffering merely cannot be judged by this method.

Theoretically the WTP approach has the advantage that it acquires the full rage of personal cost associated with the illness. However, WTP approach is criticized in the context of “existence” values, which do not derive from private consumption of a good (Kahneman & Knetsch, 1992). It has also been noticed that the results are sometimes subject to personal interpretations of questions and can be biased by respondents’ desire to engage in strategic behavior (Diamond & Hausman, 1994).

5.2 Conclusions

It is evident that no study is complete as they do not consider all measurable cost components and have some limitations in respect of methods used in estimating cost. The results of the COI studies show considerable variation, due to variations in pollution exposure levels, differences in health care systems etc. Moreover, due to differences in the data and methods, COI estimates are not comparable across studies. Nevertheless, some important insights emerge from the analysis of the results obtained from our review.

This review highlights the large uncertainties involved in estimating societal cost associated with air pollution. Particularly, uncertainties are about the existence of health effect and to statistical uncertainties about the value of coefficients. For methodological concern, to reduce these uncertainties, the appropriate approach should be used as to set up a dose-response relationship for single country pollutants. Monetary valuations should also be imputed by the countries own estimates and by different socio-economic groups (e.g. to estimate productivity losses). However, policy concerned on environmental pollution management should not be restricted within the single country border. It would be better if such decisions present a concerted effort involving countries with in the same region (Quah & Boon, 2003).

5.3 Future Research

It is expected that this review could identify some gaps and limitations in existing research. Based on these, we recommend that in future research, standard COI guidelines should be followed without omission of key cost components and quantify with theoretical justification. To understand the consequences of air pollution and to estimate accurate societal cost, future research should also be directed and given efforts towards producing better data, preferably longitudinal data. To date, air pollution related cost-of-illness studies mostly based on prevalence-based COI framework. To fulfill this important gap, future research should be based on an incidence-based COI framework. Although our initial intention was also to review COI study on noise pollution related ill-health, however, due to lack of COI study associated with noise pollution it was not possible to fulfill our aim. Therefore, to fill an important research gap in this area, future research should also be intended for COI study associated with noise pollution related ill- health.

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