Economic cost of mortality due to traffic induced air pollution: a VSL approach

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Abstract

In this paper an effort is made to estimate cost of mortality due to traffic induced air pollution for urban commuters of Bengaluru city, India. Being ubiquitous phenomenon of urban world, often traffic congestion is cursed for long waiting hours imposing opportunity cost of lost time on society. But an implied negative consequence of such long traffic hours can be seen on the health of commuters. Higher vehicular density due to traffic congestion tends to elevate the pollutant's concentration to which commuters are exposed causing severe health issues which could lead to mortality incidence. Cities of developing countries are facing much worst problem of road congestion, which led air pollution as leading factor of mortality. Air quality of most Indian cities is degrading mainly due to vehicular emission. On this background, the study has conducted estimation of mortality cost for major metropolitan city of India, Bengaluru and estimated that the value of statistical life for traffic-induced emission mortality would account for an average 0.4 percent of city's GDP.

Keywords: Value of statistical life; mortality; human capital approach; traffic emissions; air pollution; road congestion; discount rate.

Introduction

Being ubiquitous phenomenon of urban world, often traffic congestion is cursed for long waiting hours imposing opportunity cost of lost time on society. But an implied negative consequence of such long traffic hours can be seen on health of commuters. Higher vehicular density due to traffic congestion tend to elevate the pollutant's concentration to which commuters are exposed causing severe health issue which could lead to mortality incidence. The issue gets more severe in case of cities of developing countries especially in India due to unprecedented growth in vehicular population coupled with improper urban transport planning causing traffic congestion gridlock. HEI (2019) recently reported that, among top ten developing countries with highest mortality attributable to air pollution, India ranks second in position, next to China. Further a study by OECD estimated a death toll of air pollution from transport sector (mainly due to PM) to be around US$ 4.16 million in the year

2010 (OECD, 2014). The study attributed lack of control over vehicular emission is the main cause of mortality in India, which resulted in 12 percent increase in number of deaths and three percent increase in years of life lost.

World Bank (2002) approximated that 20 percent of India's health burden can be attributed to urban air pollution and is responsible for 1.4 percent of total mortality, 0.5 percent of DALYs and 2 percent of cardiopulmonary diseases (Ezzati, 2002; Cohen, 2004). A study by CPCB (2011) reported that urban air pollution is growing in recent years (1990 to 2010) mainly due to increasing private vehicular ownership. Vehicles are reported to contribute 72 percent of total urban air pollution followed by industries (20 percent) and domestic activities (8 percent) mainly in Indian cities (Navade et al, 2002). TERI (2015) also reports similar findings stating that automobile emission is one of the major sources of air pollution in most Indian metropolitan cities. In case of India, it is estimated that approximately 1.2 million premature deaths in 2017 is caused by air pollution (HEI, 2019) and more than half of it can be attributed to road transport related pollution.

Numerous research studies have estimated the cost of air pollution, but high pollutants' density at traffic junctions remains matters of serious concern. Motor vehicles emit large quantities of carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (Nox), particulate matter (PM) and other anthropogenic substance whose density increases at traffic junctions which cause adverse effects on health of commuters. There are significant number of studies which have proved the relationship between exposure to traffic-related air pollution and global burden of mortality (HEI, 2010). But such studies are lacking in case of Indian metropolitans. Efforts to estimate the source-specific cost of pollution will aid for specific policies to aim at reduction of air pollution. For this, the present study has made an attempt to assess the impacts of traffic related air pollution Bengaluru city, as the city is staggered with vehicular population and pollution. The major rationale behind the selection of the city is, being one among the major metropolitan city of the country, it is found only in Bengaluru that, 40 percent of air pollution is contributed by vehicular emission (TERI, 2015) and Bengaluru has been ranked among cities with worst traffic congestion by IBM (2011) study.

The present paper is organized into five sections: *first section* deals with traffic related air pollutants and its epidemiological evidence; *second section* reviews literature on estimation of mortality cost; *third section* provides methodology adopted for the study and *fourth section*

brings out the economic cost of mortality due to traffic related air pollution; *final section* concludes with policy implications.

SECTION I

Traffic-related Air pollutants and Epidemiological[1] Evidence

It is common to believe that vehicular emission tend to have negative health impact but the present study is in effort to examine that in traffic congestion, due to high vehicular density, the impact of emissions on health would be very severe. To prove this hypothesis, the study relies on the epidemiological evidences from the literature as medical enquiry is not the scope of the present research. In this section, the study brings out the major pollutants from automobiles followed by epidemiological evidences for these pollutants.

1.1 Traffic-related Air Pollutants

Among wide range of spatial scale effect of traffic-related air pollutants, the highest direct exposures are likely to occur at local scale mainly in a traffic-stuck vehicle or on a road side of traffic junctions. The study limits its scope to traffic junctions rather than road side of the junctions.

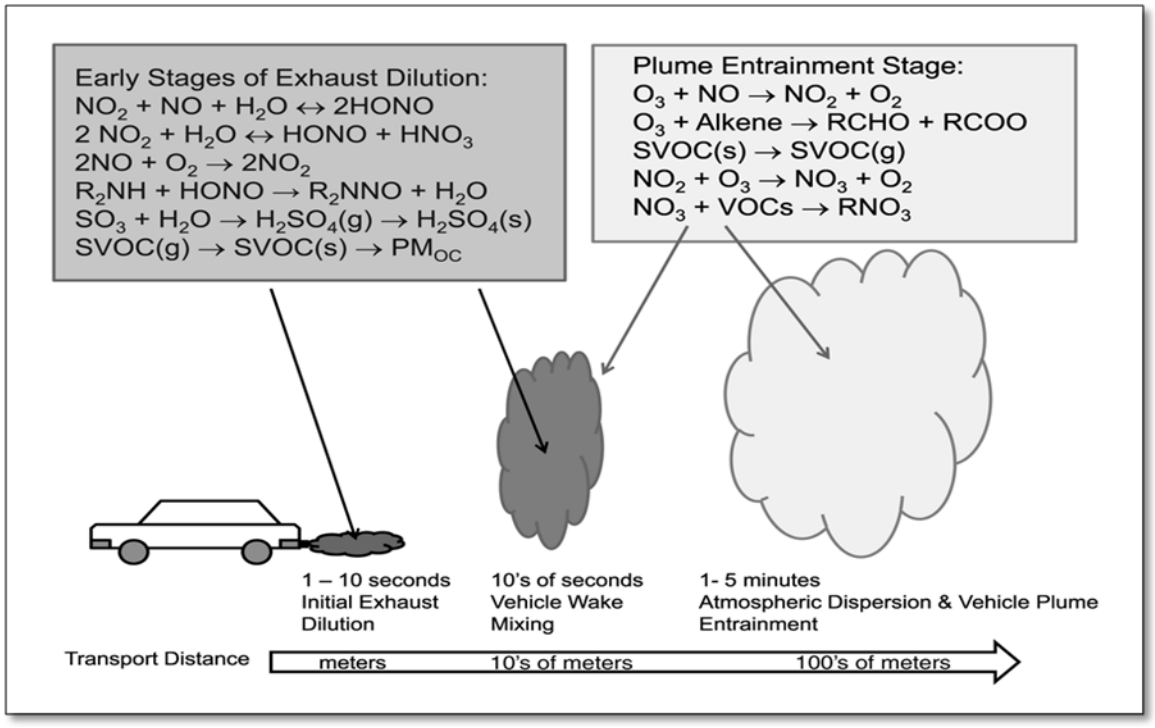
Vehicular emissions can be classified into primary pollutant and secondary pollutant. Primary pollutants are the one which get generated at source and then dispersed. In case of vehicular pollutant, primary pollutant are carbon di oxide, carbon monoxide, hydrocarbon, particulate matters (PM), nitrogen oxide and substances called mobile source air toxics like benzene, form-aldehyde, acetaldehyde, 1,3-butadiene. Secondary pollutants are formed due to chemical interactions with air. For example, oxidation of NO turns into NO_2 and ozone (O_3). Further pollutants are related to type of vehicle (light or heavy duty vehicles), age, operating and maintenance condition, type and quality of fuel used on road.

The concentration of pollutants gets severe in road side location especially in traffic junctions. Queued up vehicles near traffic signals with their engines running tend to have high emission and also significant population gets exposed to pollutant. For example, average concentration of $PM_{2.5}$ in-vehicle was 2.5 times higher and CO was six times higher than concentration nearby urban site (Chan CC et al. 1991; Adams et al. 2001; Kaur et al. 2005).

[1] Study of distribution and determinants of health related events (diseases) (WHO)

The early stage of exhaust contains CO_2, H_2O, CO, NO, NO_2, HC, semi volatile organic compounds, inorganic materials and PM from exit of tailpipes at relatively high temperature and concentration. This exhaust plume will mix with (entrain) background air and there is possible of chemical diffusion-limited reaction taking place. This phenomenon is very localized and likely to affect exposure that occurs within 100m of the source. This means, commuters in the traffic junctions have high exposure to these pollutants. At greater distance, traffic emissions are more likely to mixed with other sources and are difficult to apportion. Hence, the study will account for population who are travelling daily and are assumed to be exposed to these pollutants.

Figure 1: Schematic representation of possible chemical transformation of motor-vehicle emissions



Source: HEI, 2010

1.2 Health Effects of Traffic Related Air pollutants: Epidemiological Evidences

WHO's environmental health criteria for assessing human exposure define transport air pollution exposure to include concentration of pollutants in $\mu g/m^3$ or any other equally valid

metric; duration of exposure; setting like workplace and transport mode and exposed population (WHO, 2005). Based on this definition, the study considered that in general, people who commute and spend time in traffic, which has elevated concentration, are expected to have high exposure to pollution and prone to health impacts. Though people spend less time in traffic junctions, they are exposed to high level of pollutants as described earlier due to rush hour travel. For instance, it is estimated that 40,000 cases of mortality can be attributed to air pollution, of which half of all mortality has been linked to motorized traffic (Kunzil et al., 2000).

1.2.1 Impact on health by type of pollutants

Notable studies have proved that criteria pollutants[2] have adverse effect on human health (Pervin et al., 2008). Motor vehicle emissions have variety of effects on human health which varies from itchy eyes to chronic lung disease or heart failure (McCubbin and Delucchi, 1999). WHO (2016) reported that increased PM pollution created substantial burden of disease in EU. It can take form of loss of productivity, morbidity and mortality impacts. This section elaborates major vehicular pollutants and their possible health impacts.

Particulate Matter (PM): PM pollution proved to be greatest threat to human health (Hoek et al., 2002) especially among urban population. PM_{10} and $PM_{2.5}$ are the major pollutants from vehicle combustion. Due to wide range of chemical constituents, structure and size of particles, it can have a variety of physiological and biological effects (McCubbin and Delucchi, 1999). Since the chemical composition and its impact differ from one source to another, it is important to identify the kind and size of particles which are more harmful to human health. There is exhaustive literature which indicated that smaller particles are more harmful than larger (Review of literature in HEI, 2010[3]) that is $PM_{2.5}$ can cause higher impact than $PM_{10.}$ Some studies have found linkage between chronic cough, chronic phlegm, wheezing, chest illness and bronchitis (reported in McCubbin and Delucchi, 1999). Studies by Abbey et al (1993; 1995 as reported in McCubbin and Delucchi, 1999) found significant linkage between TSP and PM_{10} and chronic respiratory illness among adults of California.

[2] Criteria pollutants are non-toxic air pollutants (CO, NO2, PM, SO2, lead, ozone), excess concentration of these would be hazardous to health.

[3] These are cohort studies

Carbon Monoxide (CO): It is obvious that traffic-related CO would be highest in vehicles in traffic junctions (HEI, 2010; U.S. EPA 2000). One major impact of carbon monoxide is it binds with hemoglobin in the blood to form carboxyhemoglobin. This reduces oxygen carrying capacity of the blood and limits the release of oxygen from circulating hemoglobin (McCubbin and Delucchi, 1999). Heart troubles (EPA, 1991) and headaches (Schwartz and Zeger, 1990) are linked to CO. Studies by reviewed in McCubbin and Delucchi (1999) provided compelling evidences for cardiovascular problem due to increased exposure to CO may increase the risk of death especially among people with coronary artery disease.

Nitrogen dioxide (NO_X): NO_X accounted for 33 percent of on-road vehicular emission in United States in 2007 (HEI, 2010). NO_X pollutants are considered to be secondary pollutant as they mix with atmospheric components. Schwartz and Zeger's (1990) study estimated that NO_2 exposure would lead to minor respiratory symptoms like excess phlegm and eye irritation

Table 1 Traffic related pollutants and possible health impacts

Pollutant	**Short term impact**	**Long term impact**	**Source**
Fine Particulates $PM_{2.5}$ and PM_{10}	Hospital admission for respiratory disease; Exacerbated lung and heart condition	Premature death; affects quality of life	COMEAP, 2009; AQEG, 2012
Ozone (O_3)	Respiratory irritation, asthma	Cardiovascular disease through prolonged inflammatory effects on lungs; myocardial infarction and cardiac arrhythmias in older people	WHO, 2005
Nitrogen dioxide (NO_2)	Bronchocontriction, increased bronchial reactivity, airway inflammation	Decreased pulmonary function, inflammation of lung and immunological changes	COMEAP, 2010

Exposure to these pollutants inflicts wide range of illnesses from minor breathing issues to cardiovascular morality. In fact, mortality impacts of traffic air pollution are complex to establish as it has long duration of illness suffered.

1.3 Mortality impacts: Epidemiological Evidences

Identifying the impact of traffic-related air pollution on health is quite challenging. Studies conducted in recent years (especially in developed countries like Europe) provide strong association of death, particularly from fine PM of motor vehicle emissions (WHO Regional office for Europe, 2003). The studies were driven by the magnitude of impact estimate of traffic-related air pollutants on mortality in terms of its costs to society. Though literature is filled with studies on air pollution and its association to mortality, this section provides evidence only for traffic-related mortality evidences. An important consideration made here is that, mortality due to traffic emissions is associated with persistent exposure and prolonged incidence of morbidity.

Dockrey et al, (1993) and Pope et al, (1995) found association between average PM and mortality from cardiopulmonary diseases and lung cancer in their study. Schwartz et al. (2002) analyze the data from six cities study in the United States using source apportionment techniques, showed that 3.5 percent increase in mortality per 10 $\mu g/m^3$ increase in traffic-related $PM_{2.5}$ from combustion source of traffic, showing a linear association with mortality. Hoek et al., (2002) showed in a cohort study that there is an increased risk of death for people living close to major roads in Netherlands. The study found pronounced effect on cardiopulmonary mortality causing 1.34 percent increase per 10 $\mu g/m^3$ increase in traffic-related black smoke. In a retrospective study on occupational exposure to pollution, Stern et al (1988) found high cases of mortality from arteriosclerotic[4] heart disease among tunnel officers in New York City which was attributed to motor vehicle emission. In prospective study on professional drivers in London showed that there is an increased case of death among lorry drivers due to bronchitis, asthma and lung cancer (Balarajan & McDowall, 1988). A similar study was conducted on male bus drivers in Sweden and found that there is a 50 percent increase in mortality from myocardial infarction among drivers due to automobile emission (Alfredsson et al., 1993).

Eliasson et al, (2009) estimated that 20-25 death can be attributed to traffic-related air pollution in inner city and around 25-30 death in metropolitan area, based on Stockholm study. Another study by Jerrett et al, (2005) analyzed the relationship between

[4] Related to myocardial infarction.

cardiopulmonary deaths among the residents of Los Angeles, California and found the relative risk of 1.12 percent for every 10μg/m^3 increase in $PM_{2.5}$.

COMEAP (2009) quantified that chronic health of PM exposure in terms of mortality as, 6 percent increase in death rate per 10μg/m^3 $PM_{2.5}$ concentration. The study examined again in the year 2010 (COMEAP, 2010) and reported that reduction in 1μg/m^3 of $PM_{2.5}$ would result in a saving of approximately 4 million life years or an increase in 20 days life expectancy in people born in 2008.

SECTION II

Literature Review on Estimation of Mortality Cost due to Air Pollution

Economic valuation of air pollution largely based on role of individual preference in valuing the environmental damage (Shin et al, 1992). There are two broad categories of valuation techniques to estimate the costs of air pollution viz, physical linkage approach and behavioural linkage approach. Physical linkage method also called as damage function approach estimate the effects of pollution with the application of market prices (Ligus, 2018). Behavioural linkage approach, on the other hand, is based on the behavioural changes due to environmental damage[5]. There are number of studies which have used these methods to derive the air pollution cost estimates.

In recent literature, estimating the mortality cost using value of statistical life has become quite popular. Pioneering work is found in the studies of Viscusi et al (1991) and Krupnick and Cropper (1992). They derived VSL for avoiding statistical case of chronic bronchitis. In estimation of VSL related to air pollution, prominent work is by WHO (1995) which used both COI and HCA approach to estimate the economic value of air pollution which accounted for approximately US$ 2,102 million per year. McCubbin and Delucchi (1999) adopted valuing statistical life for mortality and cost of illness for morbidity for Los Angeles, USA and reported that cost of automobile emitted PM_{10} emissions would be US$ 401,260 million. The study reported mortality cost ranged from US$ 5,093 million to $48,062 million and morbidity cost would range from US$ 2,727 million to $38,924 million for PM emission in Los Angeles. The main drawback of the study is it relied on meta analysis.

[5] An elaborated explanation of these methods is provided in section III.

Loehman et al (1994) used WTP method to value the benefits associated with improved air quality in San Francisco Bay Area. They identified the households who have shifted from one air quality area to another and their average WTP were collected which was ranged from US$6 to US$73 per month (1980 dollar).

Larson et al (1999) examined the impact of PM emissions from 29 stationary sources in city of Volgograd, Russia. Using WTP approach, it is reported that the benefit of 25 percent reduction in mortality risk would provide US$40 million per year. Using human capital approach (HCA), El-Fadel et al (2000) estimated economic value of mortality and morbidity in Lebanon urban area. They examined PM_{10} emissions and reported that $10\mu g/m^3$ reduction would benefit from savings out of emergency hospital visit worth of US$0.05 to 1.9 million every year. Friedrick and Bickel (2001) estimated a loss of 6.3 million euro to Europe due to $10\mu g/m^3$ increase in PM_{10} emissions at discount rate of 10 percent. Hammitt and Zhou (2006) estimated value of statistical life of three health outcomes associated with air pollution: cold, chronic bronchitis and death. The study was conducted in Beijing, China in 1999 and reported the VSL range between US$ 4000 to US$ 17,000 million.

From the literature evidence, the study found that there is dearth of research studies in case of developing country like India. Being one of the major developing countries in the world, Indian cities are the main engines of economic growth, imprinting their significance in world economy. Among them, Bengaluru stands unique in the list due to its IT status. In this background, the next section elaborates methodology and data used for the estimation of mortality cost due to traffic induced air pollution.

SECTION III

Methodology and Data Material

Value of statistical life is the trade-off rate between money and small risk of death. The term stresses the probabilistic nature of the valuation and distinguishes it from the amount that individuals are willing to pay to save identified lives. VSL follows the measure of optimal deterrence. It is the risk-money trade offs for very small risk of death. Often VSL is viewed as ‘price tag’ on life, but economists believe that life is invaluable and VSL is just trade off for small mortality risk.

3.1 Approaches to estimate VSL

A common measure of mortality is human capital approach (HCA). This uses foregone earnings to measure increase in life expectancy. Life of an individual is valued as the discounted sum of his future income given that his wage is equal to the value of marginal product. Another approach used to estimate value of mortality risk for developing countries is the Benefit Transfer method (BTM). Under this VSL is estimated from extrapolating the values from developed countries. This approach has been criticized mainly on the grounds that risk preferences of people in two countries are different. Further, another common approach to VSL is through estimating willingness to pay for risk reduction. For this there are two methods: contingent valuation method and revealed preference method.

The revealed preference method depends on hedonic values of goods that are indirectly measure. General method of revealed preference is hedonic wage approach. But in case of developing countries wages provided distorted indication of true value. In case of contingent valuation method which estimates the WTP, there are methodological constraints of creating proper hypothetical market and this method also assumes that respondents are fully aware of the case under study.

Owing to methodological simplicity and ease of policy implication of HCA approach the present study made an effort to estimate VSL for traffic induced mortality reduction for Bengaluru city.

3.1.1 Human Capital Approach (HCA)

In this approach the productivity loss due to pollution induced disease is measured by earning of his labour (Freeman, 1979). OECD (1989) developed this approach as the product of numerical value of number of people affected or dead and the amount cost of treatment or death will provide the monetary value of health damage. It is derived as the numerical value for statistical life and work day lost due to morbidity and mortality respectively.

In case of mortality, the human capital approach measures the cost of death by numerical value for statistical life. This value considers the value of future earning based on the present value of individual’s income with appropriate discount rate. According to Mishan (1982) the value of statistical life would be

$$VSL = \sum_{n}^{t} w/(1+d)^t$$

Where d is the discount rate, t is the remaining life span and w is the wage rate.

This method involves estimating individual's discounted life years. There are few issues needs to be addressed for estimating VSL in this method.

1. The method assumes that premature death has certain work day lost which can be valued by future earning based on present value of earnings.
2. The method requires a suitable discount rate for the population under study.

The major issue to be addressed in this method is adopting suitable discount rate (as this method is highly sensitive to the discount rate). The discount rate indicates the amount of future utility that an individual would require for waiting. This explains the concept of time preference. There are two types of time preference: individual time preference, which involves preference for private decisions and societal time preference considers the societal well being (Lawless, Nayga & Drichoutis, 2013). There are many options to opt the discount rate, one is to use base value as zero, and other is to derive opportunity cost of capital and last is to adapt interest rate on low risk bonds (Shanmugam, 2000). Since, the objective of the present study is to account for the mortality cost for the entire study area, societal time preference discount rate would provide better results. For this, the study can adopt low risk bond interest rate (Viscusi, 1995). Hence, to arrive at better results, the study estimated the VSL using three discount rates. The rationale is provided in Table 2.

Table 2: Discount rate and the rationale

Discount rate (%)	**Rationale**
0	It provides base reference
8	This is the low risk bond interest rate in 2018
12	This is derived in the study of Zhuang et al (2007)

This method estimates the value of human capital as the present value of his/her future earnings under the assumption that future earning can be a proxy for future productivity. Major drawback of this method is it does not capture the intangibles like pain and suffering.

Further the method is sensitive to discount rate particularly if the population under study includes children.

3.2 Study area and Data material used for the study

The study is conducted for India's one of the major metropolitan city, Bengaluru. The city is staggered with private vehicular ownership with annual growth rate of 10 percent, which is not supported by growth in adequate road infrastructure (growing at less than 1 percent)[6]. Further, the city has been ranked as worst city for traffic movement by IBM in 2011. With these evidence, and also study by TERI (2015) reported that Bengaluru city's air pollution is majorly contributed by vehicular emissions (40% of RSPM from vehicles), the present study selected the city to conduct health survey. For the present paper, we have derived the major elements required for estimating VSL like remaining life span and average income of the commuters. A sample of 427 commuters was interviewed regarding their socio-economic details, commuting pattern and health status. With the multi-stage random sampling method, city was divided into four major zones which included commuters from different sections of job market.

SECTION IV

Estimation of Mortality Cost of Traffic induced Air Pollution

The formula to estimate the VSL based on human capita approach is:

$$VSL = \sum_{n}^{t} w/(1+d)^{t}$$

Where d is the discount rate, t is the remaining life span and w is the wage rate. To derive t (remaining life span) for the study sample, the study has considered the average age as 34 years and life expectancy as 62 years and hence, the remaining life span would be 28 years. The average income of the study area is Rs. 35,000/month[7]. The VSL for three different discount rates is estimated in the Table 3.

Table 3: VSL values based on the discount rates

[6] Author's Calculation based on Transport Department of Karnataka data 2001-2018.
[7] Based on Sample survey.

Discount rate (%)	VSL (in Rs.)
0	10,15,000
8	4,21,788
12	3,14,455

Source: Author's estimation

These values need to be multiplied with the number of deaths. For the Bengaluru city, the mortality rate for 10µg/m^3 increase in PM is taken as 0.22 percent. Hence, the excess death using this rate for the working population (25,28,380[8]) for the city would be 5562 persons. The economic cost of mortality would be

Table 4: Cost of Mortality with discount rates

Discount rate (%)	Cost of mortality (in crores)
0	564.58
8	234.61
12	174.91

Source: Author's estimation

As stated earlier the VSL results from HCA approach are very sensitive to discount rate. Zero discount rate indicate that individuals value the present earning more than the future earning, which may not be practical. Though eight percent discount rate seems to be practical which will reflect the low risk bond interest rate of the Indian economy, usually developing countries' discount rate would be much higher than this (Zhuang et al, 2007). Based on this present study considers 12 percent discount rate and reports the economic cost of mortality as Rs. 174.91 crores per year due to traffic related air pollution.

SECTION V

Policy implication and Conclusion

This paper is an attempt towards estimating the value of mortality due to traffic induced air pollution. Though there are various methodological controversies regarding the estimates of VSL, it is regarded as standard method of estimation. In this regard, the present study has estimated the value of statistical life for Bengaluru commuter's mortality risk due to PM emitted by vehicular congestion. The estimated VSL for the city is on an average Rs. 174.91

[8] Based on Census 2011 data

crores (or US $ 24.43 million[9]) which account for 0.4 percent of city's GDP (2017-18). Similar result is found in other studies quoted in the literature section. This value indicates the average loss to the economy due to vehicular pollution in the city and directs the policy makers to address the issue of automobile emissions with urgency. The need of the hour policy is to introduce higher fuel quality standard to Indian cities with strict enforcement of EURO VI and proper management of traffic movement in the core of the city. Further, there is need to develop the public transport system with frequency and reliability concern which would shift the private vehicular ridership to public transport by reducing the emission concentration and exposure, bringing improvement in air quality and commuter health.

References

1. Adams HS, Kenny LC, Nieuwenhuijsen MJ, Colvile RN, Gussman RA (2001) Design And Validation Of A High Flow Personal Sampler For $PM_{2.5}$. *Exposure Anal Environment Epidemiology*. 11:5-11.
2. Alfredsson L et al. (1993). Incidence of myocardial infarction and mortality from specific causes among bus drivers of Sweden. *International Journal of Epidemiology*. 22: 57-61.
3. AQEG (Air Quality Expert Group) (2012). Fine Particulate Matter ($PM_{2.5}$) In the United Kingdom. Prepared for the Department of Environment, Food and Rural Affairs; Scottish Executive; Welsh Government; and Department of the Environment in the Northern Ireland. London: Defra. Retrieved 12 June 2019 From www.gov.uk/government/uploads/system/uploads/attachment_data/file/69635/pb13837-aqeg-fine-particle-matter-20121220.pdf.
4. Balarajan R and McDowall MR (1988). Professional drivers in London: A mortality study: *British Journal of Industrial Medicine*. 45: 483-486.
5. Chan CC, Ozkaynak H, Spengler JD, Sheldon L (1991). Diver Exposure to Volatile Organic Compounds, CO, Ozone And NO_2 Under Different Driving Conditions. *Environment Science Technology*. Vol 25. Pp: 964-972.
6. Cohen AJ, Inskip HM, Linaker CL, Smith S, Schreiber J, Johnston SL, Holgate ST (2004). Personal Exposure Air Pollutants and Severity of Induced Asthma in Children. Lancet. 361: 1939-1944.
7. COMEAP (Committee On The Medical Effects Of Air Pollutants) (2009). Long Term Exposure To Air Pollution: Effect On Mortality. A Report By The COMEAP. Didcot:

[9] US $ in 2019 prices

Health Protection Agency. Retrieved 22 August 2019 From www.comeap.org.uk/images/storeis/documents/reports/mortality%20report$202009.pdf.

8. COMEAP (Committee on the Medical Effects of Air Pollutants) (2010). The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in The United Kingdom. A Report by COMEAP. Didcot: Health Protection Agency. Retrieved 28 August 2019 From www.hpa.org.uk/webc/hpawebfiel/hpaweb_c/1317137012567.
9. CPCB (Central Pollution Control Board) (2011). Air Quality Standards in India. Central Pollution Control Board and Ministry Of Environment and Forest, Government Of India.
10. Dockery DW, Pope CA, Xu XP, Spengler JD, Ware JH, Fay ME, Freeris Jr. BG, Speizer (1993). An Association between Air Pollution and Mortality in Six Cities. New England *Journal of Medicine*. 329: 362-373.
11. El Fadel And Massod M (2000). Particulate Matter In Urban Areas: Health Based Economic Assessment. *The Science of The Total Environment*. 257: 133-146.
12. Eliasson J, Hultkrantz L, Nerhagen L, Rosqvist LS (2009). The Stockholm congestion-charging trail 2006. Overview of effects. *Transportation Research Policy Practice*. 43(3): 240-250.
13. Ezzati M, Lopez AD, Rodger A, Vander Hoorn S, Murray CJ (2002). Comparative Risk Assessment Collaborating Group. Selected Major Risk Factors and Global And Regional Burden Of Disease. Lancet. 2(360): 1347-1360.
14. Farber S And Rambaldi A (1993). Willingness To Pay For Air Quality: The Case Of Outdoor Exercise. Contemporary Policy Analysis XI (October 1993). 19-30.
15. Freeman III M (1979). The Benefits Of Environmental Improvement: Theory And Practice. *Resource for The Future*. Washington, DC.
16. Friedrich R, Bickel P (Eds.) (2001). Environmental External Cost of Transport. Springer-Verlag Berlin Heidelberg GmbH. New York.
17. Hammitt, J. K and Zhou Y (2006). The Economic Value of Air-Pollution-Related Health Risks in China: A contingent valuation Study. *Environmental and Resource Economics*. 33(3): 399-423.
18. Health Effect Institute (HEI) (2019). State of Global Air 2019: A special report on Global exposure to air pollution and its disease burden. Boston: MA. Health Effect Institute.
19. HEI Panel on The Health Effects Of Traffic Related Air Pollution. (2010). Traffic-Related Air Pollution: A Critical Review Of The Literature On Emission, Exposure And Health Effects. HEI Special Report 17. Health Effect Institute: Boston. MA.

20. Hoek G, Brunekreef B, Goldbohm S, Fischer P, Van Den Brandt PA (2002) Association Between Mortality And Indicators Of Traffic-Related Air Pollution In The Netherlands: A Cohort Study. Lancet 360: 1203-1209.
21. IBM (2011). Frustration Rising: IBM 2011 Commuter Pain Survey. IBM. Accessed from http://www.profacility.be/piclib/biblio/pdf_00000552UK.pdf
22. Jerrett M, Brunett RT, Ma R, Pope III CA, Krewski D, Newbold KB, Thurston G,Shi Y, Finkelstein N, Calle EE, Thun MJ (2005) Spatial Analysis Of Air Pollution And Mortality In Los Angeles. *Epidemiology* 16: 727-736.
23. Kaur S Et Al (2005) Personal Exposure Of Street Canyon Intersection Users To $PM_{2.5}$, Ultrafine Particle Counts And Carbon Monoxide In Central London. UK. *Atmospheric Environment*. 39:3629-3641.
24. Krupnick A and Cropper M (1992). The effect of information on Health risk valuations. *Journal of Risk and Uncertainty*. 5: 29-49.
25. Kunzil N et Al. (2000) Public-Health Impact Of Outdoor And Traffic-Related Air Pollution: European Assessment. *Lancet*, 356(9232): 795-801.
26. Larson BA, Avaliani S, Golub A, Rosen S, Shaposhnikov D, Strukova E, Vincent JR, Wolff SK (1999). The Economics Of Air Pollution Health Risks In Russia: A Case Study Of Volgograd. World Development. 27(10): 1803-1819.
27. Lawless, L.J., Nayga, R., and Drichoutis, A. (2013). Time Preference and health behaviour: A review. Munich Personal RePEc Archive (MPRA) (Paper No. 45382). Retrieved 21/12/2018 from, http://mpra.ub.uni-muenchen,de/45382/.
28. Ligus M (2018). Measuring the Willingness to Pay for Improved Air quality: A contingent valuation survey. *Polish Journal of Environmental Studies*. 27(2): 763-771.
29. Loehman (1979). Distributional Analysis of Regional Benefits And Cost Of Air Quality Control. *Journal of Environmental Economics and Management*. 6: 222-243.
30. McCubbin RD And Delucci MA (1999). The Health Cost Of Motor Vehicle Related Air Pollution. *Journal of Transport Economics And Policy*. Vol 33 (3). 253-286.
31. Mishan (1982). Cost Benefit Analysis: An Informal Introduction. 3rd Edition. George Allen And Unwin, Sydney.
32. Navade K, Kumar AV, Patil RS, Nambi KSV (2002). Source Apportionment Of Suspended Particulate Matter At Two Traffic Junctions Of Mumbai India. *Atmospheric Environment*. 35: 4245:4251.
33. OECD (Organization For Economic Co-Operation And Development) (1989). Environmental Policy Benefits: Monetary Valuation. Paris.

34. Organization for Economic Cooperation and Development (OECD) (2014). The Cost of Air Pollution: Health Impacts of Road Transport, OECD Publishing. http://dx.doi.org/10.1787/9789264210448-en
35. Pervin T, Gerdtham G, Lyttkens CH (2008). Societal Cost of Air Pollution-Related Health Hazards: A Review of Methods and Results. *Cost Effectiveness and Resource Allocation*. Biomed Central. 6(19) Accessed From www.resoure-allocation.com/content/6/1/19
36. Pope III CA, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FB, Heath CW (1995) Particulate Air Pollution As A Predictor Of Mortality In A Prospective Study Of US Adults. *American Journal of Respiratory And Critical Care Medicine*. 151: 669-674.
37. Schwartz J And Zeger S (1990) Passive Smoking, Air Pollution And Acute Respiratory Symptoms In A Diary Study Of Student Nurses. *American Review of Respiratory Disease*. 141: 62-67.
38. Schwartz J et al (2002). The concentration-response relation between $PM_{2.5}$ and daily death. *Environmental Health Perspectives*. 110(10): 1025-1029.
39. Shanmugam, K. (2000). Valuation of life and injury risks-Empirical evidence from India. *Environmental and Resource Economics*. 16:379-389.
40. Shin E, Gregory R, Hufschmidt M, Lee YS, Nickum JE, Umestu C (1992). World Bank - Economic Valuation of Urban Environmental Problems. Report Washington DC.
41. Stern FB, Halperin WE, Hornung RW, Ringenburg VL, McCommon CS (1988). Heart Disease Mortality among Bridge And Tunnel Officers Exposure To Carbon Monoxide. *American Journal of Epidemiology*. 128: 1276-1288.
42. The Energy and Resource Institute (TERI) (2015). Air Pollution and Health. Discussion Paper by The Energy and Resource Institute: New Delhi.
43. U.S. Environment Protection Agency (EPA) (2000) Air Quality Criteria For Carbon Monoxide Final Report. EPA 600/P-99/001F. U.S. EPA Office Of Research And Development. National Centre For Environmental Assessment. Washington, D.C.
44. United States Environmental Protection Agency (1991) Air Quality Criteria For Carbon Monoxide. EPA/600/8-90/045F. Office Of Research And Development. Washington DC. December.
45. Viscusi W K (1995). Discounting Health Effects for Medical Decisions, Valuing Health Care. In S A Frank (eds), Valuing Health Care Costs, Benefits and Effectiveness of pharmaceutical and other medical Technologies (pp, 125-147). Cambridge University Press.

46. Viscusi WK, Magat WA, Huber J (1991) Pricing Environmental Health Risks: Survey Assessments Of Risk-Risk And Risk-Dollar Trade-Offs For Chronic Bronchitis. *Journal Of Environmental Economics And Management*. 21: 32-51.
47. WHO (2005). Health Effects of Transport-Related Air Pollution. (Eds) Michal Krzyanowski, Birgir Kuna-Dibbert and Jurgen Schneider. WHO Regional Office for Europe, Copenhagen, Denmark.
48. WHO Regional Office For Europe (2003). Health Aspects Of Air Pollution With Particulate Matter, Ozone And Nitrogen Oxide. Report On WHO Working Group. Bonn, Germany, 13-15 January 2003. Copenhagen, WHO Regional Office For Europe. Accessed 15 July 2018 From http://www.euro.who.int/document/e79097.pdf.
49. World Bank (2002): World Bank Infrastructures And Energy Services Department Europe And Central Asia Region. Urban Transport In The Europe And Central Asia Region: World Bank Experience And Strategy. Washington, DC. World Bank (Report No. 25188 ECA; http://wbln0018.worldbank.org/eca/transport,nsf/3355693bf49ed34985256c4d004873dd/751dd38b86409bbe85256cb5005a57/ad/$file/ecauts-dec$2002.pdf. Accessed 25 May 2019.
50. World Health Organization (1995). Assessment of sources of air, water, and land pollution. A guide to rapid source inventory techniques and their use in formulating environmental control strategies. Part I. Rapid Inventory techniques in environmental pollution. By AP Economopoulos. Geneva (WHO/PEP/GETNET/93.1-A).
51. World Health Organization (WHO) (2016). Ambient Air Pollution: A Global Assessment of exposure and burden of disease. Geneva: Switzerland. WHO.
52. Zhuang, J, Liang, Z, Lin, T and Guzman, D. F (2007). Theory and Practice in the choice of Social Discount Rate for Cost-Benefit Analysis: A Survey. ERD Working Paper No. 94. Asian Development Bank.