


Air Pollution and Health

Discussion Paper

One of the main outcomes of the United Nations Conference on Sustainable Development (Rio+20) was the agreement by Member States to launch a process to develop a set of Sustainable Development Goals (SDGs). The goal 3 “Ensure healthy lives and promote well-being for all at all ages” aims at securing a healthy life for all. Measures to achieve this goal involves substantially reducing the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination. This paper discusses the health impacts arising from ambient and household air pollution globally and at the national level (India) and recommends policy measures to reduce the health impact from air pollution in the national context.

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Introduction

Clean air is the foremost requirement to sustain healthy lives of humankind and those of the supporting ecosystems which in return affect the human wellbeing. Release of various gaseous emissions and particulate matter (PM) has been on the rise due to rampant industrialized growth Anthropogenic emissions of various kinds are being pumped into the atmosphere (called primary pollutants) and lead to the formation of new pollutants due to chemical reactions in the atmosphere (called secondary pollutants). These are building up the concern of ambient air pollution (AAP) as a prominent global threat to human health in many ways. For instance, according to the Fifth Assessment Report of the IPCC 'nearly all the non-CO_2 climate-altering pollutants are health damaging, either directly or by contributing to secondary pollutants in the atmosphere'.

The UN General Assembly's Open Working Group (OWG) on Sustainable Development Goals forwarded to the Assembly its proposal for a set of goals that consider economic, social and environmental dimensions to improve people's lives and protect the planet for future generations at the conclusion of the Group's thirteenth and final session at UN Headquarters on 19 July 2014. The proposal contains 17 goals with 169 targets covering a broad range of sustainable development issues, including ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests. The goal 3 "Ensure healthy lives and promote well-being for all at all ages" aims at securing a healthy life for all. There are 9 sub-goals to this goal and sub-goal 3.9 targets to substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination by 2030.

It is essential that the hazardous impacts from environmental pollution are regularly reported and monitored. Of the various kinds of pollution, the air pollution has attracted high priority in respect of environmental regulation since the environmental damage due to such pollution mostly affects human well-being directly by way of adverse health effects on the population exposed to it. Air quality has deteriorated in most large cities in India, a situation driven by population growth, industrialization and increased vehicle use. Integrated air quality management (AQM), which is an evaluation and monitoring tool, is a challenge to carry out in most developing countries because of the lack of information on sources of air pollution and insufficient ambient air monitoring data that is available in the public domain (TERI 2009).

Urban air pollution is largely a result of combustion of fossil fuels that are used in transportation, power generation, industrial sector, and other economic activities. Household air pollution (HAP), also known as indoor air pollution (IAP), is a serious area of concern in rural spaces, as majority of this population continues to depend on traditional biomass for cooking and space heating and depend on kerosene or other liquid fuels for lighting, all of which are highly likely to lead to high levels of HAP. More than 70% of the population in India depends on traditional fuels (firewood, crop residue, cow dung, coal and lignite) for cooking and almost 32% depend on kerosene for lighting purposes. About 3 billion people in the world (more than 40% of the global population) rely on traditional biomass for the purpose of cooking and an estimated 500 million households rely on kerosene and similar for the purpose of lighting (WHO, 2015). In rural India, for instance, only 11.4% of the households use LPG for cooking (Census 2011).

This chapter discusses the health impacts arising from ambient and household air pollution and recommends policy measures to reduce the health impact from air pollution. The focus of the paper is on the global burden of air pollution and recommendations to reduce air pollution in the national context.

Parameters of air quality

Air pollution consists of a complex mix of various substances in different physical and chemical states and these arise from various sources. Many of them are believed to be gravely harmful to human health. Eminent international institutions like the World Health Organisation (WHO) consider a certain set of air pollution indicators to get closer to quantification and monitoring of air pollution as quantification of all the air pollutants has not yet been feasible on a global scale. WHO focuses on four health-related air pollutants, namely, particulate matter (PM), measured as particles with an aerodynamic diameter lesser than 10 µm (PM_{10}) and lesser than 2.5 µm ($PM_{2.5}$), nitrogen dioxide, sulfur dioxide and ozone. The focus on just these four is for the sake of monitoring the general state of air quality and it does not mean that the other air pollutants do not impact health of humans and that of the environment (WHO, 2006).

Figure 1 and Figure 2 give the annual mean concentration of PM_{10} and $PM_{2.5}$ in different regions of the world respectively. For both the figures, the data represented belongs to years in the period 2008-2012 since this data is available for different years for the different stations. The highest and the lowest recorded values of PM_{10} and $PM_{2.5}$ for each region are represented in these two figures. The WHO guideline values for particulate matter are 20 µg/m^3 for PM_{10}, 10 µg/m^3 for $PM_{2.5}$, 40 µg/m^3 for NO_2 and 20 µg/m^3 for SO_2 . The orange line denotes the WHO limits. The red dots plotted over each country's bar graph in both the figures represent the HDI value for that country as reported in the year 2012.

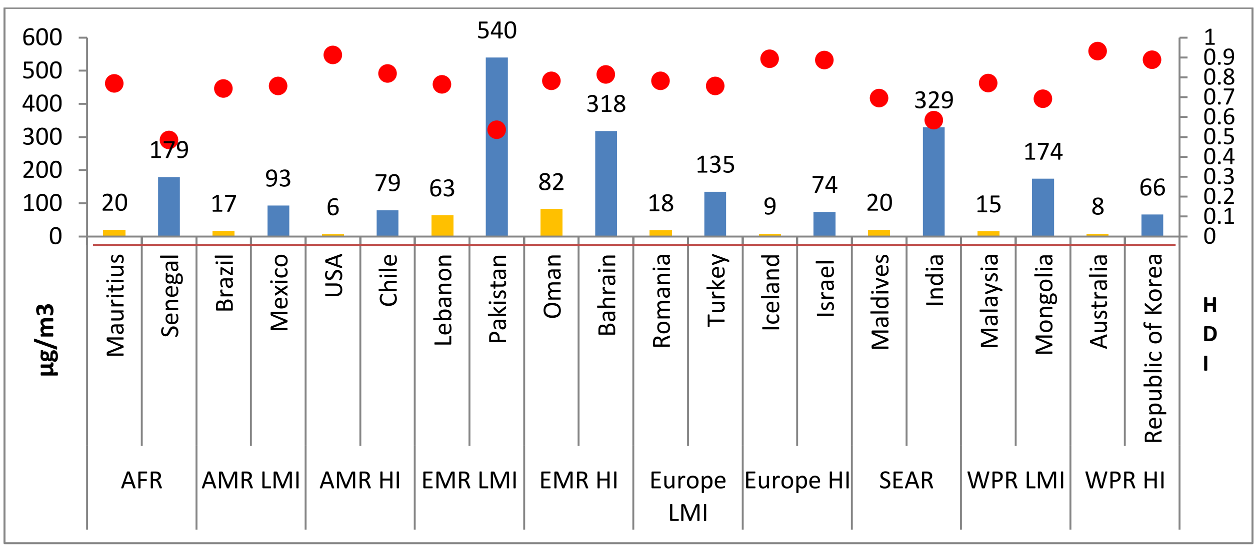

Figure 1: Annual mean concentration of PM_{10} (ug/m^3) in regions of the world[1]

Note: Yellow bar denotes lowest value for the region and blue bar denotes highest value for the region. These are based on data for a particular region and are not average values for a region. The orange line denotes the permissible limit of 20 µg/m^3 The red dots depict the HDI value

Source: Ambient Air Pollution Database, WHO (2014)

[1] AFR (Africa), AMR (America), AMR (America), EMR (Eastern Mediterranean Region), SEAR (South-East Asia Region), WPR (Western Pacific Region), HI (High-Income), LMI (Low and Middle Income)
City/station at the specific countries whose data is presented: Mauritius (Midlands), Senegal (Dakar), Brazil (Salvador), Mexico (Mexico City), USA (Lake Havasu City-Kingman, Arizona), Chile (Rancagya), Lebanon (Beirut), Pakistan (Peshawar), Oman (Muscat), Bahrain (Hamad Town), Romania (Galati), Turkey (Igdir), Iceland (Hafnarfjordur), Israel (Ashkelon), Maldives (Male-Friday Mosque Station), India (Gwalior), Malaysia (Tanah Rata), Mongolia (Darkhan), Australia (Illawarra), Republic of Korea (Cheongju)

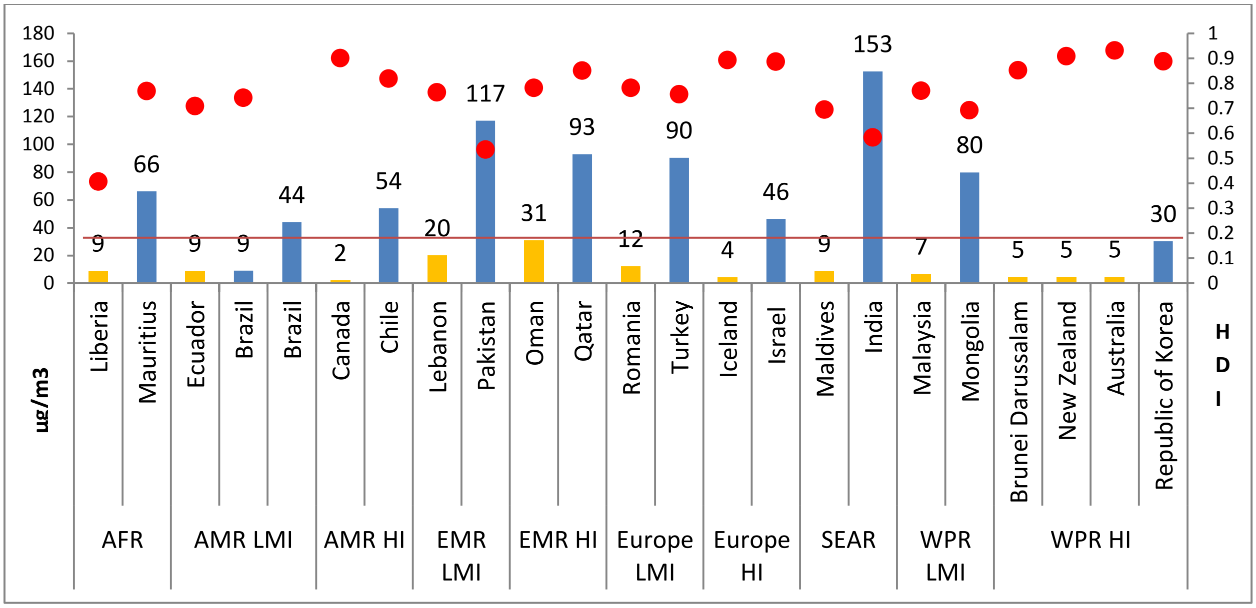

Figure 2: Annual mean concentration of $PM_{2.5}$ (ug/m3) in regions of the world[2]

Note: Yellow bar denotes lowest value for the region and blue bar denotes highest value for the region.These are based on data for a particular region and are not average values for a region. The orange line denotes the permissible limit of 30 µg/m3. The red dots depict the HDI value

Source: Ambient Air Pollution Database, WHO (2014)

In Figure 1, for PM_{10}, the highest recorded level is in EMR LMI, where the value recorded comes from a station (Peshawar) in Pakistan. The lowest recorded level is in WPR HI, where the value recorded comes from a station (Illawarra) in Australia. In Figure 2, for $PM_{2.5}$, the highest recorded level is in SEAR, where the value recorded comes from a station (Delhi) in India. The lowest recorded level is in AMR HI, where the value recorded comes from a station (Powell River) in Canada. Generally, the high income group countries have lesser PM_{10} and $PM_{2.5}$ values than the low income group countries except in the case of $PM_{2.5}$ concentration in Chile. The highest value of $PM_{2.5}$ in AMR HI (in Chile) is greater than the highest value in AMR LMI (in Brazil). Overall, the EMR and SEAR are faring the worst in terms of PM_{10} and $PM_{2.5}$ amongst other regions of the world. It is interesting to note that some countries that have high PM_{10} and $PM_{2.5}$ values have lower HDI values and some countries that have less PM_{10} and $PM_{2.5}$ values have higher HDI values. This does not mean to state that there is necessarily a connection between the two but it hints towards understanding of the specific context of these countries and their respective stage of development.

Ambient air pollution has been identified as a national problem since it is the fifth biggest cause of mortality in India (Atkinson, Cohen, Mehta, et al. 2011). Central Pollution Control Board (CPCB) in India implements the National Air Quality Monitoring Programme through a network comprising 544

[2] AFR (Africa), AMR (America), AMR (America), EMR (Eastern Mediterranean Region), SEAR (South-East Asia Region), WPR (Western Pacific Region), HI (High-Income), LMI (Low and Middle Income)
City/station at the specific countries whose data is presented: Liberia (Buchanan rural), Mauritius (Beau Bassin/Rose Hill, Coromandel), Ecuador (Ibarra, Ambato), Brazil (Salvador; 9 µg/m^3, Santa Gertrudes; 44 µg/m^3), Canada (Powell River), Chile (Rancagya), Lebanon (Beirut), Pakistan (Karachi), Oman (Muscat), Qatar (Doha), Romania (Galati), Turkey (Igdir), Iceland (Hafnarfjordur), Israel (Modiín), Maldives (Male-Friday Mosque Station), India (Delhi), Malaysia (Tanah Rata), Mongolia (Darkhan), Brunei Darussalam (Brunei-Muara District), New Zealand (Lower Hutt), Australia (Melbourne), Republic of Korea (Cheongiu).

operating ambient air quality stations covering 224 cities/towns in 26 states[3] and 5 union territories of the country.

Under NAMP three major pollutants viz. PM_{10} (Particulate Matter having an aerodynamic diameter less than or equal to 10 µm), Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2) have been identified for regular monitoring at all locations. The permissible levels of PM_{10}, NO_2 and SO_2 are 60, 50 and 40 µg/m^3. Other parameters like $PM_{2.5}$ (Particulate Matter having an aerodynamic diameter less than or equal to 2.5 µm), Carbon monoxide (CO), Ammonia (NH_3), Lead (Pb), Ozone (O3), Benzene (C_6H_6), Benzo (a) pyrene {B(a)P}, Arsenic (As) and Nickel (Ni) are being monitored at selected locations and are slowly being added to the monitoring network under NAMP. CPCB gives ambient air quality data in different cities of India. More than 80% of the Indian cities violate the PM_{10} standards. Only 31 cities meet the standard of 60 µg/m^3 for PM_{10} out of 204 cities for which data exists. Almost all the cities in India except for Dombivali (52) and Ulhasnagar (46) lie below the permissible limit of 50 µg/m^3 for SO_2 and there are 9 cities which exceed the permissible limit of 60 µg/m^3 for NO_2. (More details about the average annual concentration for different cities in India is given in Annexure 1).

Air Pollution Impacts on Respiratory Health

In 2012 alone, 7 million deaths in the world were attributable to the combined effects of ambient (3.7 million) and household (4.3 million) air pollution (WHO, 2015). Figure 3 shows the leading causes of deaths and premature deaths in the world (as of 2010). Ischemic heart disease is at the forefront in this ranking of causes, and COPD, lower respiratory infections, lung cancer are also amongst the top five causes of deaths worldwide.

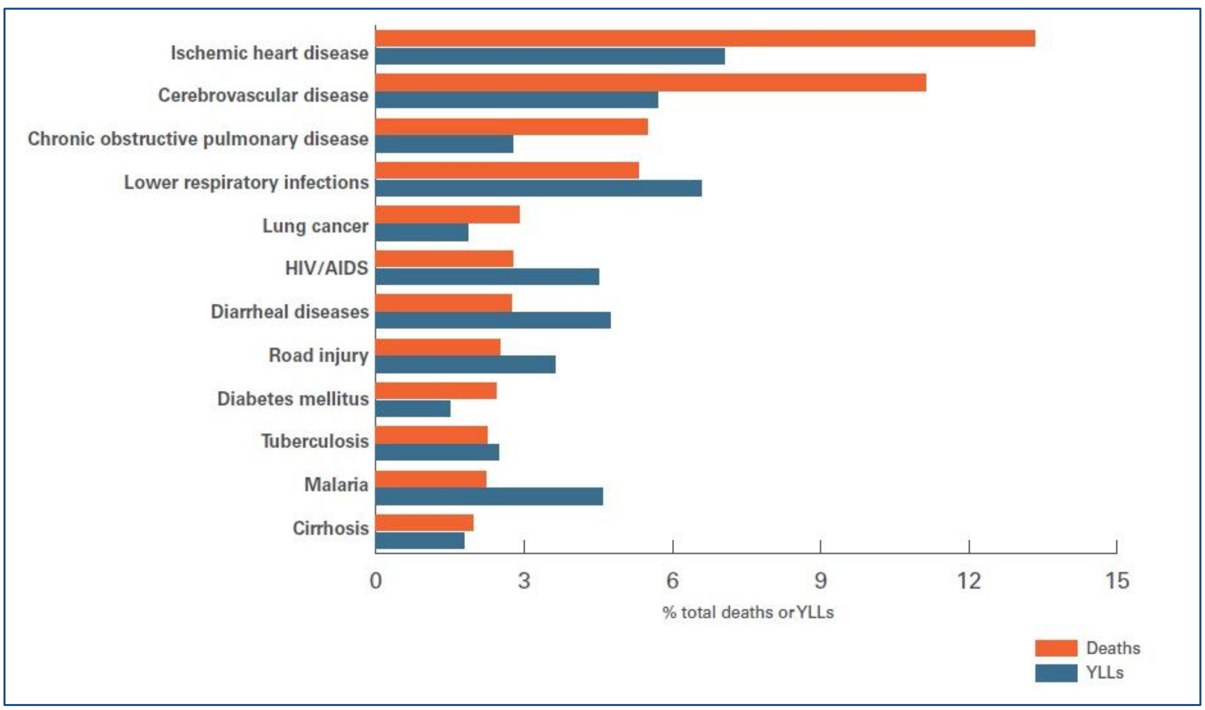

Figure 3: Leading causes of global deaths and premature deaths
Source: Global Burden of Disease (2010)

[3] States of Manipur and Sikkim are not covered by CPCB.

Figure 4 depicts the total number of deaths in 2012 that are attributable to household air pollution (HAP) and ambient air pollution (AAP) across all the regions of the world. As part of an update on the Global Burden of Disease (GBD) Study 2010, it was found that essentially five different kinds of respiratory health conditions are the causes behind the number of deaths. About 36% of the deaths are said to be attributable to Ischaemic Heart Disease (IHD), 33% to stroke, 17% to Chronic Obstructive Pulmonary Disease (COPD), 8% to Acute Lower Respiratory Disease (ALRI) and 6% to lung cancer. The update also quantifies the effect on people from different gender and age groups. According to it, 49% of the 7 million in 2012 were men (aged 25 years or above), 42% were women (aged 25 years or above) and 9% were children (under the age of 5 years) (WHO, 2014). Deaths in Western Pacific low and middle income region is the highest in the world, followed by South-East Asia and then by Africa.

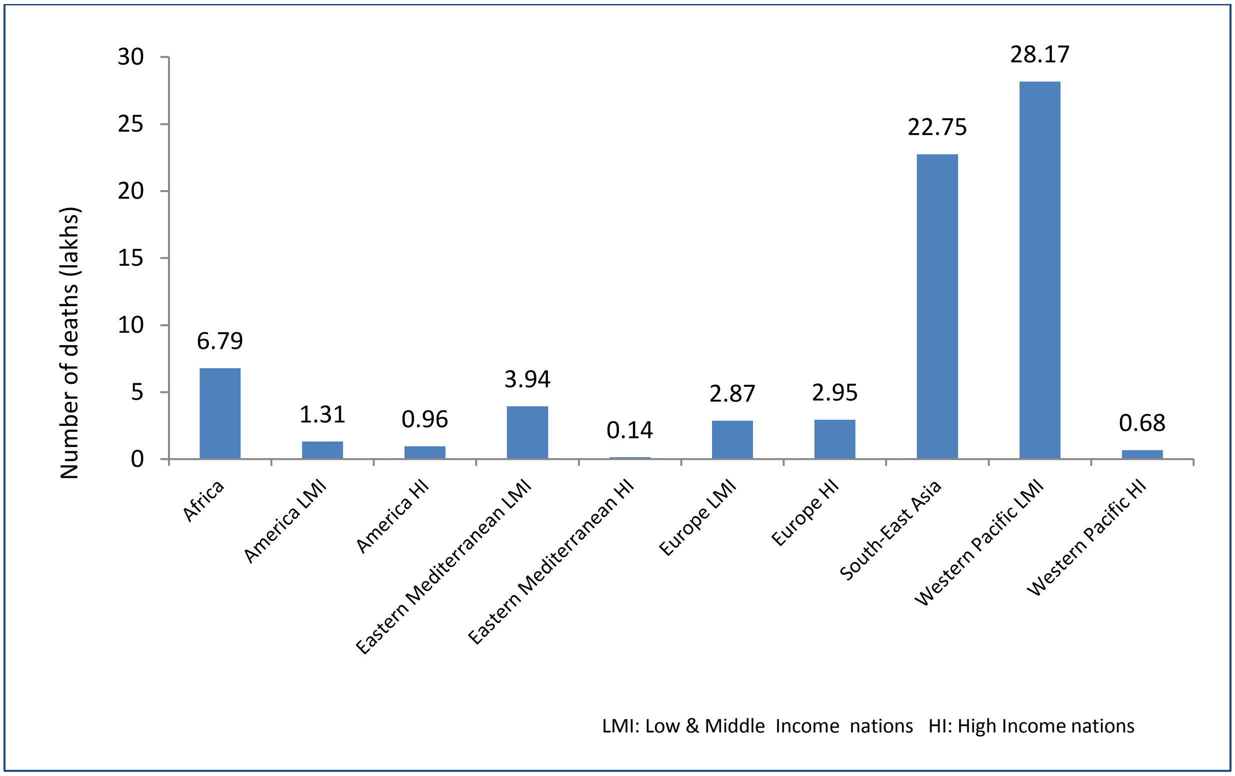

Figure 4: Total global deaths attributable to household and ambient air pollution in 2012 (region-wise)
Source: WHO 2014

Table 1 presents data for every five years from 1990 to 2010 for the percentage of total global deaths due to causes attributed to air pollution categorized under three main diseases. As per the data observations, it can be said that the total global deaths due to all the major respiratory diseases seem to be reducing systematically for the time period in consideration. This is also due to the improvements made over these years, 1990 to 2010, in the quality, accessibility and availability of health services and medicines, that are being provided to the geographical areas where treatment from the illnesses are required. There is insufficient data to be able to state that the percentage of total global deaths that are attributed to air pollution have reduced over these years due to improvements in global air quality, if any.

Table 1: Percentage of total global deaths due to causes that are attributed to air pollution

Years	Chronic obstructive pulmonary disease	Lower respiratory infections	Pneumoconiosis	Other chronic respiratory diseases	Total
1990	6.7	7.3	0.4	0.6	15
1995	6.3	6.7	0.3	0.6	13.9
2000	5.7	6.1	0.3	0.5	12.6
2005	5.4	5.5	0.2	0.5	11.6
2010	5.5	5.3	0.2	0.6	11.6

Source: WHO 2015[4]

Global life expectancy for both sexes increased from 65.3 years in 1990 to 71.5 years in 2013, while the number of deaths increased from 47.5 million to 54.9 million over the same interval which means that improving healthcare is pushing the average age-bar of the global population, also leading to the inference that we have less younger population now than we had in earlier years. Respiratory infections have a major impact on child health and especially of those less than five years of age, as the ambient and household air pollution begins to affect the child health even before birth and during the prime years of growth. Lower respiratory infection remains as one of the top five causes of death in children under five years (IHME, 2013). Figure 5 illustrates the significant decline in the number of global deaths of children aged 1 month to 4 years in the last decade while numbers of deaths in children fewer than 27 days has barely changed in the time period.

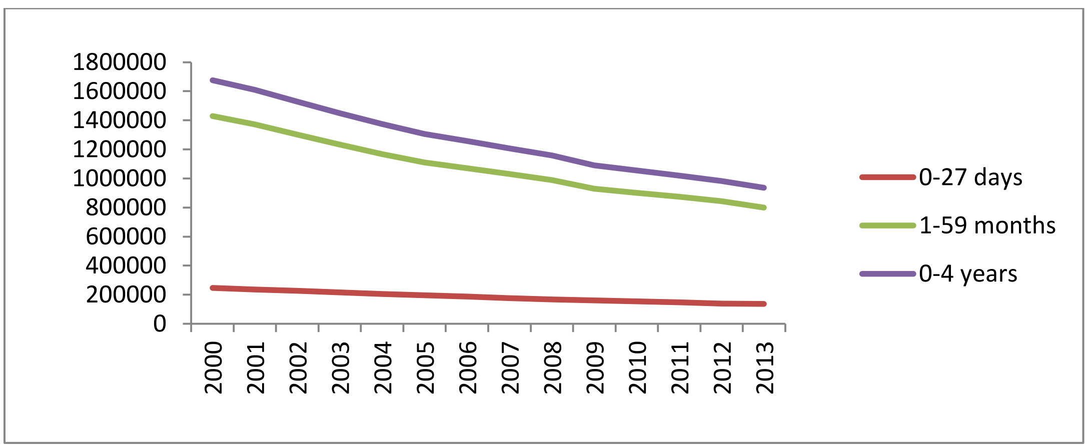

Figure 5: Number of global deaths in children due to acute lower respiratory infections
Source: WHO, 2015

Table 2 shows a detailed snapshot of the total global numbers of; years of life lost from mortality (YLL), years of health life lost due to disability (YLD) and disability-adjusted life years (DALY) for men (M) and women (F) of all age-groups, for the major communicable and non-communicable diseases that are believed to be attributed to air pollution. From the table, it can be seen that in the year 2000, respiratory infections and lower respiratory infections has the highest YLL value amongst both men and women including all age groups, has the highest YLL value amongst women in 2012 too but Ischaemic heart disease accounts for the highest YLL value for men in 2012.

[4] Institute for Health Metrics and Evaluation, website last accessed on June 1, 2015 <http://www.who.int/gho/en/>

Table 2: Total number of YLL, YLD and DALY (in millionsfor 2000 and 2012 for men and women of all age groups for the diseases attributable to air pollution

	2000						2012					
	YLL		YLD		DALY		YLL		YLD		DALY	
	M	F	M	F	M	F	M	F	M	F	M	F
Communicable diseases												
Respiratory infections	110.85	95.97	4.33	4.02	83.83	70.34	79.03	65.91	4.80	4.43	83.83	70.34
Lower respiratory infections	110.50	95.66	1.10	1.08	79.98	66.89	78.76	65.69	1.22	1.20	79.97	66.88
Upper respiratory infections	0.22	0.20	0.80	0.79	1.02	1.01	0.17	0.14	0.89	0.88	1.06	1.01
Non-communicable diseases												
Ischaemic heart disease	80.79	54.24	3.82	3.38	98.58	67.14	93.62	62.87	4.96	4.27	98.56	67.12
Respiratory diseases	51.38	39.23	21.13	20.61	76.73	60.38	50.54	35.36	26.19	25.02	76.72	60.37
COPD	36.47	28.46	12.70	11.79	52.19	40.19	36.14	25.49	16.05	14.70	52.18	40.18
Asthma	6.91	4.90	5.92	6.48	13.40	11.80	6.63	4.44	6.77	7.36	13.40	11.80
Other respiratory diseases	7.99	5.88	2.51	2.34	11.14	8.39	7.78	5.43	3.36	2.97	11.14	8.39

Note: (YLLs) is the years of life lost from premature mortality, (YLDs) is the years of life lived with any short-term or long-term health loss and Disability-adjusted life years (DALY) is the sum of years lost due to premature death (YLLs) and years lived with disability (YLDs). DALYs are also defined as years of healthy life lost.
Source: WHO (2015)

Indian cities today are among the most polluted areas in the world and it is estimated that outdoor air pollution leads to approximately 670,000 deaths annually (Lim et al., 2013). Current standards, for particulate matter set by the CPCB are much higher than those recommended by the World Health Organization (Krzyzanowski and Cohen, 2008). In addition, unlike other countries (Bell et al., 2003; Dominici et al., 2007), the CPCB does not take into account findings from health literature when deciding on air quality standards (Balakrishnan et al., 2011). A periodic review of epidemiological evidence informs policy makers about current health risks associated with air pollution and sets the agenda towards finding a balance between reducing health impacts and the costs of implementing further air pollution controls (IIM 2014). An interesting finding of the analysis is that cities such as Ahmedabad and Mumbai that have higher levels of pollution experience a relatively lower increase in mortality for every 10 mg/ m^3 increase in PM_{10}. In contrast, the percentage increase in mortality is highest for Shimla which is among the cleanest cities. The percentage increase in mortality associated with a 10 mg/m^3 increase in PM_{10} is highest for Shimla (1.36%) and the least for Ahmedabad (0.16%). Bangalore and Mumbai showed similar results with a 0.22% and 0.20% mortality increase respectively at a 95% Confidence Interval.

Findings suggested that small reductions in pollution in cleaner cities will yield large health benefits, whereas in less cleaner cities, even large reduction in pollution may yield only modest health benefits in a relative sense. (WHO, 2006) and (WHO, 2013) state that all-cause daily mortality is estimated to increase by 0.2–0.6% per 10 μg/m3 of PM_{10} and long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary mortality by 6–13% per 10 μg/m3 of $PM_{2.5}$. The Harvard Six Cities Study found that a 2.5 μg/m3 decrease in the annual average level of $PM_{2.5}$ was associated with a 3.5% reduction in all-cause mortality in the United States (Lepeule J et al., 2012). The study was conducted through a group of people living in six cities in the United States and whose lifestyle was followed through 1974 to 2009 to estimate the effects of air pollution on health. The study also concluded that high exposure to $PM_{2.5}$ led to increased mortality due to cardiovascular illnesses and lung cancer. Consequently, the study also stated that reduced levels of $PM_{2.5}$ could quite immediately bring out positive differences on the health of people and reduce morbidity and mortality due to illnesses arising from air pollution.

Figure 6 presents the predicted average gain in life expectancy (in months) for people aged 30 years for a reduction in average annual levels of $PM_{2.5}$ down to the WHO Air Quality Guideline annual mean level of 10µg/m^3 in 25 European cities participating in the Aphekom project that was conducted between in 2008 and 2011 (WHO, 2013). The blue line denotes the air quality guideline limit for $PM_{2.5}$. The gain in life expectancy has been predicted after calculating the effect of reduced $PM_{2.5}$ levels (down to 10µg/m^3) in each of the particular 25 cities. The study concluded that the higher the $PM_{2.5}$ levels were, the greater gain in life expectancy can be achieved if the existing levels were brought down to 10µg/m3.For instance, gain in life expectancy was found to be zero simply because the $PM_{2.5}$ levels were under the WHO limits. Similarly, gain in life expectancy was highest in Bucharest after the $PM_{2.5}$ levels were modeled and brought down to be under WHO limits.

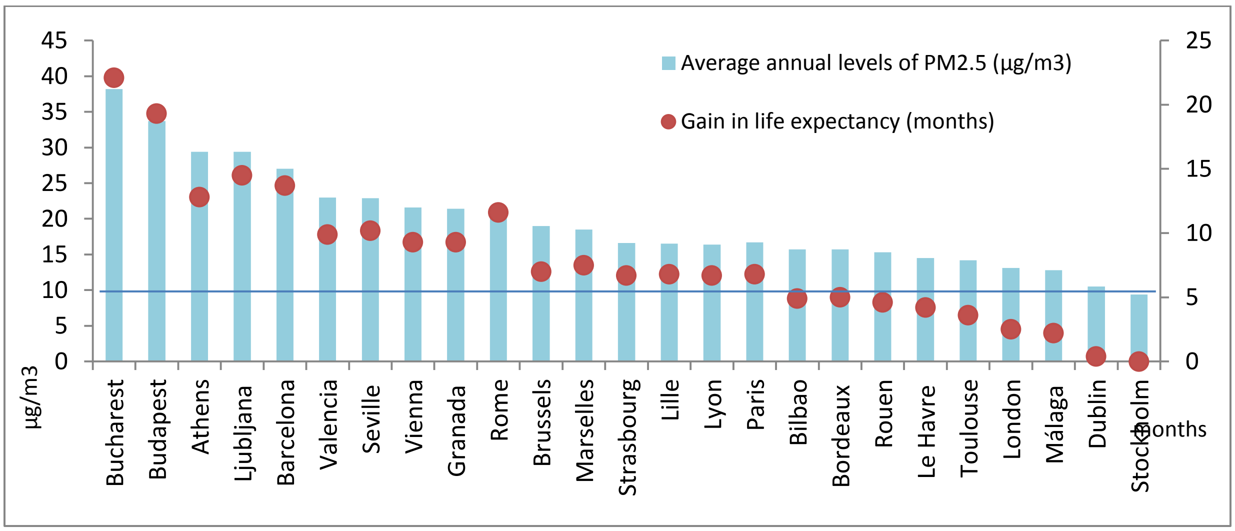

Figure 6: Predicted average gain in life expectancy with reduction in average annual levels of PM2.5 10µg/m3 in 25 European cities

Source: WHO (2013)

Ambient air pollution has been identified as the fifth biggest cause of mortality in India (Lim et al., 2012) India registered an increase of about 12% in the number of deaths and about 3% in years of life lost between 2005 and 2010. Figure 7 shows the alarming increase in the death toll in India over the period from 2005 to 2010 i.e 72000 more deaths. Figure 8 gives the disease-wise percentage distribution of deaths attributable to ambient particulate matter pollution in India.

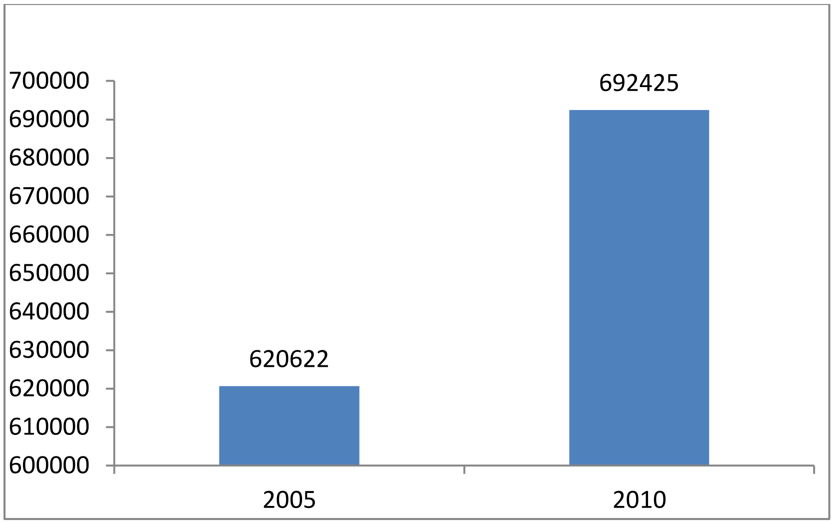

Figure 7: Total deaths from ambient PM and ozone pollution in India
Source: OECD (2014)

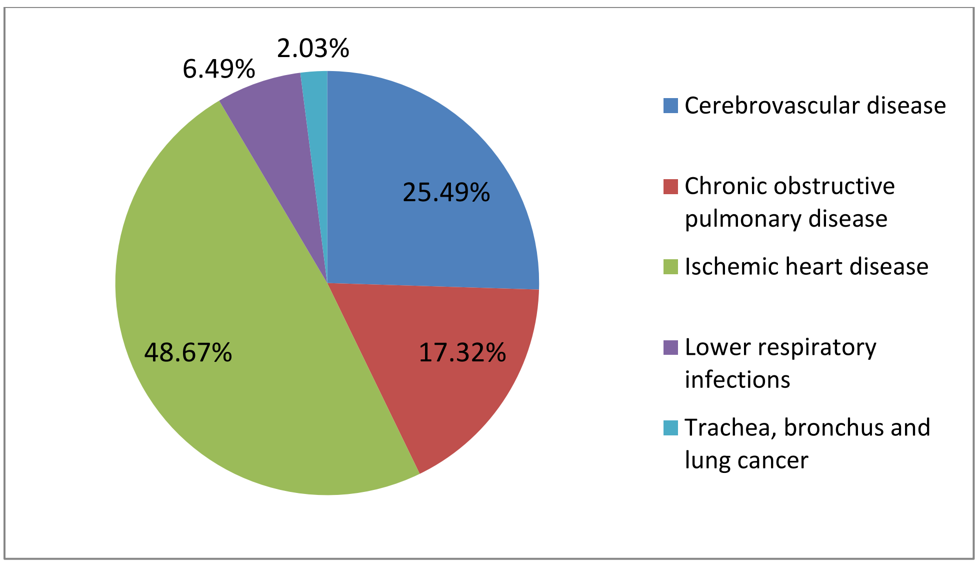

Figure 8: Percentage distribution of deaths from ambient PM pollution in India
Source: Lim et al, (2012)

There are many studies across the world and also in India to prove that outdoor and indoor air pollution is a serious environmental risk factor that causes or aggravates acute and chronic diseases. Pairing city-level air pollution measures with child level data from the National Family Health Survey (2005-06) for six cities in India shows that an increase in ambient air pollution significantly increases child morbidity (Ghosh and Mukherjee 2010). The six cities considered in the city were Chennai, Delhi, Hyderabad, Indore, Kolkata and Nagpur. The study found that a rise in ambient air pollution significantly increases the likelihood of a child suffering from cough and fever in the past week. However, the type of cooking fuel used at home is not significantly related to child morbidity after accounting for ambient air pollution and other child- and household-level control variables. Thus, while bad air is bad for child health, ambient air pollution is a more significant determinant of the child health outcomes. A significant correlation between the two child morbidity outcomes – fever and cough. Controlling citywide air pollution could significantly lower child morbidity, and should receive greater emphasis in urban planning and infrastructure development.

Indoor air quality has emerged as one of the most important issues of environment and health worldwide. Household air pollution (HAP) due to biomass cooking fuel use is an important risk factor for a range of diseases, especially among adult women who are primary cooks, in India (Lin SS et al 2010). India has recently identified HAP as one of the key indicators in its National Monitoring Framework for Prevention and Control of Non-Communicable Diseases (MoHFW 2012). Biomass fuel remains a widely used energy source in rural India where nearly 80% of households use them as the primary cooking fuel. In contrast, the majority of urban households use liquefied petroleum gas (LPG) as the primary cooking fuel; however, about 19% of urban households use biomass fuel for cooking purposes. Poverty, inaccessibility to improved cooking fuel, and lack of awareness about harms of biomass emissions are among the major factors that drive their widespread use (MoSPI 2010). Use of biomass fuel leads to harmful health effects due to the emission, during its incomplete combustion, of a large number of air pollutants such as carbon monoxide (CO), sulfur dioxide (SO_2), respirable particulate matter ($PM_{2.5}$ and PM_{10}), poly-cyclic aromatic hydrocarbon (PAH), benzene, and metals like lead and copper.

It has been estimated that about 2.4 of 5.6 million cases of chronic bronchitis, 0.3 of 0.76 million cases of Tuberculosis , 5 of 51.4 million cases of cataract among adult Indian women and 0.02 of 0.15 million stillbirths across India are attributable to household air pollution due to biomass cooking fuel (Sehgal M, Suresh R et al. 2014).

Several studies have linked biomass cooking fuel with adverse pregnancy outcomes such as preterm births, low birth weight and post-neonatal infant mortality, but very few have studied the associations with cooking fuel independent of other factors associated with stillbirths. Using India's 2003/04 District Level Household Survey II data, it has been found that usage of biomass and kerosene cooking fuels by women is related to stillbirths. Nearly 12% of these stillbirths can be prevented by providing access to cleaner cooking fuels (Lakshmi, Sharma V, et al. 2013).

Annually, 400–550 thousand premature deaths have been attributed to indoor air pollution in India (Smith, 2000). There is consistent evidence that indoor air pollution increases morbidity and mortality from respiratory tract symptoms in childhood (Hertz, Baker et al 2007). Indoor air pollution measured in terms of particulate matter <2.5µm in diameter ($PM_{2.5}$), is an important cause of respiratory illness in children. Increased $PM_{2.5}$ levels and biomass fuel use number are found to be associated with increased occurrence of respiratory illness in children (Kumar, Goel et al. 2013).

Figure 9 depicts the state-wise percentage of medically certifies deaths due to diseases of the respiratory systems. Figure 10 shows the cases of Acute Respiratory Infection(ARI) as a % of total population in the state. The red line in both the graphs depict the all India value

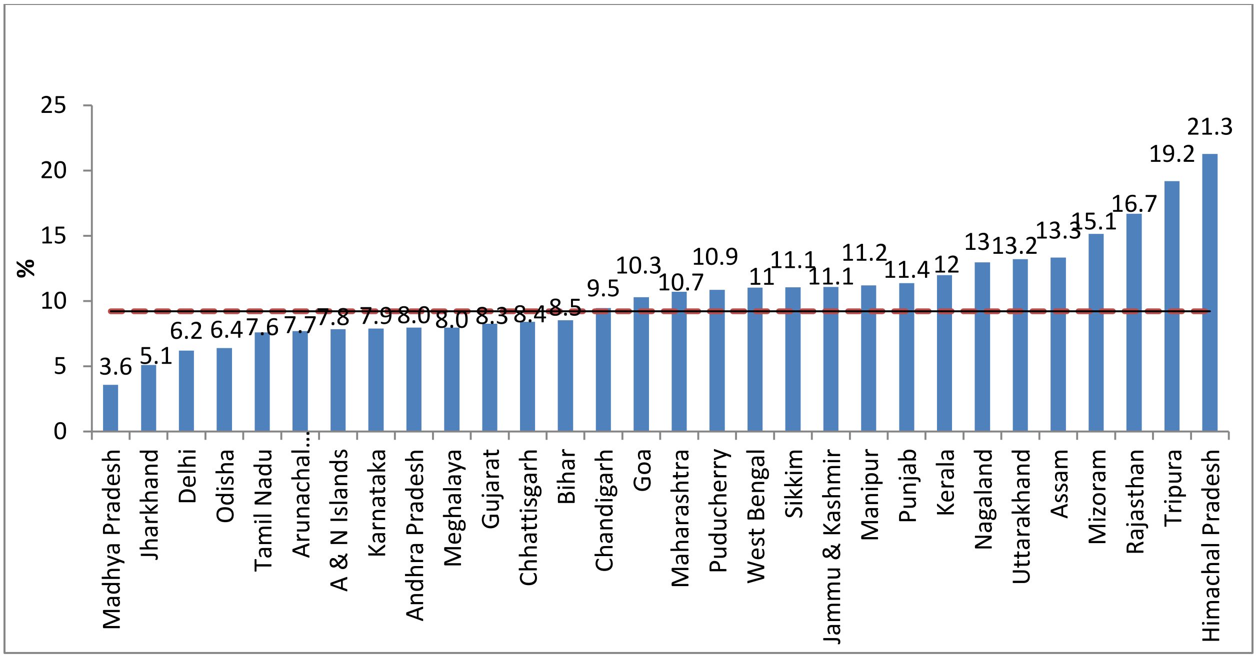

Figure 9: State-wise percentage of medically certified deaths due to diseases of the respiratory systems in 2011
Note: The red line in the graph depict the all India value of 9.71 %
Source: CBHI (2013)

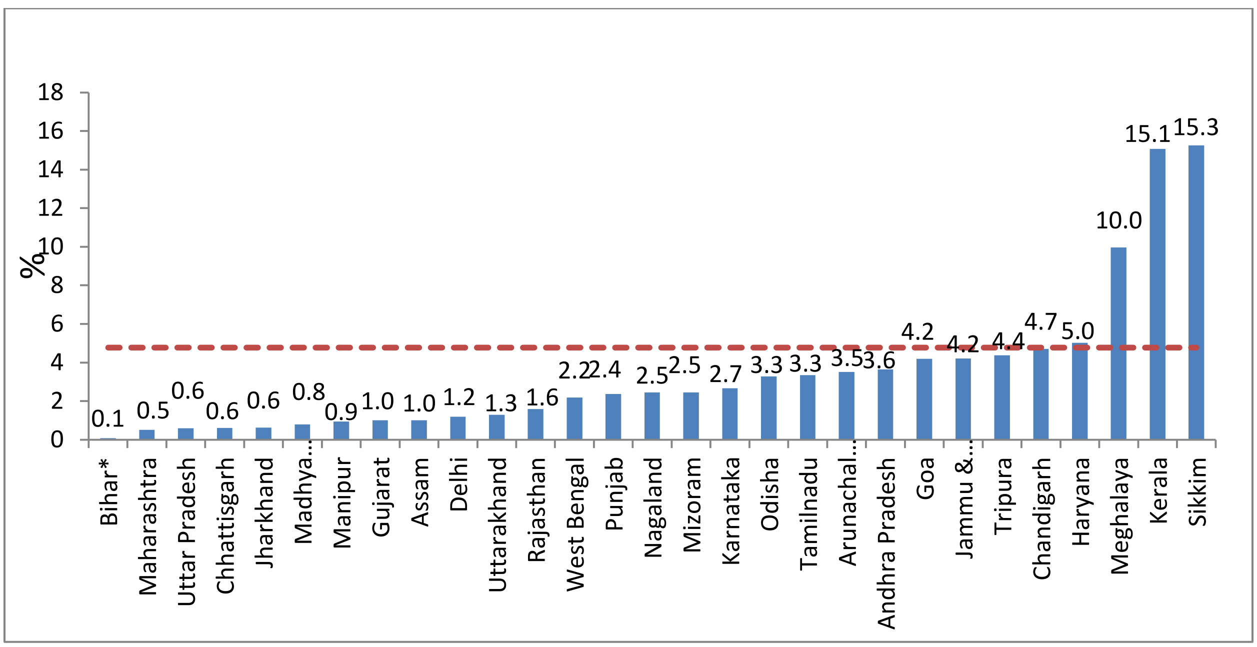

Figure 10: State-wise total cases of ARI infection deaths due to diseases of the respiratory systems in 2011.
Note: The red line in the graph depict the all India value of 4.77 %
Source: CBHI 2013

Indian metropolitan cities remain exposed to high levels of air pollutants mainly due to high vehicular movements and poor roads. Although the concentration of these pollutants vary according to the traffic density, type of vehicles and time of day; some people by virtue of their occupation are more exposed to high levels of traffic related air pollutants .These people include filling station workers, traffic policemen, professional drivers and tollbooth workers because of the proximity and high emissions from vehicle idling, deceleration and acceleration (Sehgal M , Suresh R et al 2014). In a recently conducted study on air quality monitoring ($PM_{2.5}$, CO, NO_X, SO_2 and EC/OC) at highway toll plazas, municipality toll plazas and control sites which were 23 in number, it was found that there was a high level of air pollution at almost all locations with $PM_{2.5}$ values exceeding the national permissible limit (60 $\mu g/m^3$) except at a few control sites. The study found that pollutant concentrations were highest at municipality toll plazas with minimum protective work areas. The observed reduction in lung function indices was significant over years of occupational exposure even after making adjustments for age, amongst non-smoking outdoor workers.

Economic costs of air pollution

Air pollution leads to a significant amount of mortality and morbidity. The economic cost of mortality and morbidity due to air pollution is necessary to estimate in order to determine the health costs arising from air pollution. Such cost estimates can serve as effective indicators of the economic burden of air quality-related health impact on people and on the national exchequer. Cost of mortality is estimated using Value of Statistical Life (VSL) as a measure -derived from individuals' valuation of their willingness to pay to reduce the risk of dying. India with its rapid rate of growth over this five-year period also registers a 60% increase in value of a statistical life (VSL).

Table 3 indicates the estimates of economic cost of health impacts from ambient air pollution in OECD countries, India and China for the years 2005 and 2010. Mortality and morbidity costs are reflected in USD millions. 34 OECD countries together account for 4,78,104 deaths in 2010 due to ambient air pollution while India, alone, accounts for 6,92,425. This trend has been similar in 2005 as well. It is interesting to note, however, the difference in morbidity and mortality costs in 2010 between all the OECD countries together (1.7 trillion USD) and India alone (0.4 trillion USD) is a revealing fact to understand the loss India incurs not just by the burden of disease but also economically. India's GDP in 2010 was 1.7 trillion US, which means that India was spending about 23% of its GDP value on dealing with the economic costs of health impacts from ambient air pollution. The costs in OECD countries is much higher than those calculated for India (less than four times) even while the absolute deaths in OECD countries together were lesser by over 1.2 lakhs than those in India. Similar comparative case is of OECD countries and China. Amongst the three, China has the maximum number of mortalities due to ambient air pollution. Mortalities due to this cause have increased both in India and China while it has reduced in OECD countries. The mortality and morbidity costs have changed linearly with the mortality numbers in these countries.

Table 3: Indicative estimate of the economic cost of health impacts from ambient air pollution in OECD countries, India and China in 2005 and 2010

	2005					2010				
	No. of deaths	**VSL 2005 in USD millions**	**Mortality costs, USD millions**	**Mortality + morbidity (health) costs, USD millions if add-on ~10%**	**Health costs as a percentage of GDP**	**No. of deaths**	**VSL 2005 in USD millions**	**Mortality costs, USD millions**	**Mortality + morbidity costs (health), USD millions if add-on ~10%**	**Health costs as a percentage of GDP**
OECD countries	4,97,958	..	1,470,487	~ 1,617,536	4.44%	4,78,104	..	1,571,170	~ 17,28,287	3.98%
India	6,20,622	0.375	2,32,736	~ 2,56,010	30.68%	6,92,425	0.602	4,16,704	~ 4,58,734	26.85%
China	1,215,180	0.61	7,41,019	~ 8,15,121	36.11%	1,278,890	0.975	12,46,713	~13,71,384	23.12%

Note: GDP values are in current USD
Source: OECD (2014); World Bank Data for GDP[5] , OECD (2015)

According to a World Bank study in 2009, about 1100 billion INR (1.7% of GDP) and more than 800 billion INR (1.3% of GDP) were estimated as the annual cost of environment damage caused by ambient air pollution and household air pollution, respectively, in India. This translates to that about 52% of the relative share of damage cost by environment category was due to ambient and household air pollution put together (World Bank 2013).

Data from the country's apex environmental regulator, the Central Pollution Control Board (CPCB), reveals that 77% of Indian urban agglomerations exceeded National Ambient Air Quality Standard (NAAQS) for respirable suspended particulate matter PM_{10} in 2010 (CPCB 2012[6]). Estimates from the WHO suggest that 13 of the 20 cities in the world with the worst fine particulate $PM_{2.5}$ air pollution are in India, including Delhi, the worst-ranked city[7].

Air pollution also leads to a reduction in life expectancy. Using a combination of ground-level in situ measurements and satellite-based remote sensing data, it has been estimated that 660 million people, over half of India's population or nearly every Indian (1,204 million people, or 99.5% of the population), live in areas that exceed the Indian National Ambient Air Quality Standard for fine particulate pollution. Reducing pollution in these areas to achieve the standard would, increase life expectancy for these Indians by 3.2 years on average for a total of 2.1 billion life years (Greenstone, Nilekani et al 2015).

Recommendations

There is an urgent need to adopt various strategies to improve urban and indoor air quality. To improve air quality and reduce the burden of diseases, several interventions have been adopted in India. In order to reduce vehicular pollution, CPCB set vehicular emission standards in India in 1986 for both petrol- and diesel-driven vehicles. The standards were later revised in 1987 and 1989. To curb further vehicular pollution, the Ministry of Petroleum and Natural Gas (MoPNG) has adopted the Auto Fuel Policy in 2002 which laid down a roadmap for introduction of cleaner fuels and vehicles in the country upto 2010. The Bharat Stage (BS) IV norms were implemented in 13 cities from April 2010 based on the roadmap, and

[5] http://data.worldbank.org
[6] http://cpcb.nic. in/National_ Ambient_Air_Quality_Standards.php
[7] http://www.who.int/entity/quantifying_ehimpacts/national/countryprofile/AAP_PM_database_May2014,xls?ua=1

BS III norms were implemented in entire India from October 2010. Compressed natural gas (CNG) has been introduced in many cities of the country. Heavy-duty trucks still remain on BS-III standards all across the country, although they are registered in cities where BS-IV norms have been introduced.

Auto Fuel Vision Committee was set up in 2013 to recommend the future roadmap on advancement of fuel quality and vehicular emission standards upto 2025. The committee has recommended the introduction of BS-IV and BS-V norms across the country by 2017 and 2020, respectively. BS-VI emission norms are recommended to be introduced by 2024. The roadmap recommended by the Auto Fuel Vision 2025 Committee puts India 10 years behind the US and European countries (TERI 2014). It is therefore necessary that Government of India introduces and adopts BS-V fuels than those recommended in the Auto Fuel Vision (AFV 2025) Report, by requiring and enabling the Indian refineries to leapfrog from BS-III to BS-V fuels by 2018 (ICAMP 2014).

In order to control the indoor air pollution through provision of clean energy access , government has introduced various schemes that would facilitate clean energy access such as the Rajiv Gandhi Grameen Vidyutikaran Yojana, the Village Energy Security Programme, and the Remote Village Electrification Programme. The Ministry of New and Renewable Energy (MNRE) is promoting setting up of biogas plants in all the states and union territories of the country. Biogas plants are being promoted under the scheme National Biogas and Manure Management Programme for setting up of family-type biogas plants. According to the MNRE, about 82 7003 family-type biogas plants have been set up till March 2014 against the projected target of 1.06 lakh biogas plants (TEDDY 2015).

Issues of acceptability, affordability, and poor awareness levels about alternate cooking fuels or modern technologies are the most major hurdles. On the supply side, pricing and distribution of different cooking fuels vary geographically and across demographic segments. Purely governmental planning without community participation affects the implementation and success of such schemes. Awareness generation among public and policymakers would help improve the path each community could take toward cleaner fuels.

More epidemiological studies should be taken up to determine how ambient and household air pollution is affecting people's health. Quantification of the impact is particularly insightful to provide policy the push and can act as a benchmark to understand the need for particular tools for air quality monitoring. Data gaps in quantification of the impact need to be addressed strongly and promptly, for research to be able to perform the necessary analysis and to be able to provide the most suitable policy recommendations. These data gaps also hinder further research into the matter and limit the understanding of trends in pollutant concentration levels and spread of diseases.

Given the size of the economic cost of the health effects of air pollution, the benefits of reducing that burden could easily outweigh the monetary cost of investments in more ambitious programmes to reduce pollution (OECD 2014). The best available estimate of the economic cost of the health impacts of outdoor air pollution in China and India combined is larger than the OECD total – about USD 1.4 trillion in China and about USD 0.5 trillion in India in 2010.There should be advances made in instrumentation to adopt continuous information systems for monitoring ambient concentrations and pollution from high-emitting industries or sectors (transport) . Increased monitoring can play an important role as a health advisory system and as a means of increasing pressure on polluters to comply with existing regulations. There is an urgent need of development of a sustainability index to bench mark using these components strong environmental governance- guidelines/ violators.

Annexure 1

Ambient Air Quality data in different cities in India for the year 2012

State	Cities	SO_2	NO_2	PM_{10}
	Chitoor	4	9	40
	Guntur	5	11	75
Andhra Pradesh	Hydrabad	4	28	79
	Kakinada	5	11	63
	Kothagudem	4	9	74
	Kurnool	4	15	79
	Nalgonda	5	11	62
	Nellore	6	22	108
	Patencheru	6	11	82
	Ramagundam	4	9	37
	Tirupati	6	12	97
	Vijaywada	3	11	49
	Warangal	12	13	65
	Vishakhapatnam	5	11	63
Assam	Daranga	5	13	56
	Dibrugarh	6	13	56
	Guwahati	6	14	92
	Margherita	6	15	54
	Lakhimpur	2	2	45
	Nagaon	6	13	79
	Nalbari	6	15	82
	Sibsagar	7	15	109
	Silchar	6	14	91
	Tezpur	3	9	11
	Tinsukia	5	12	57
Bihar	Patna	6	36	166
Chandigarh	Chandigarh	2	19	110
	Bhillai	8	22	103
Chhatisgarh	Bilaspur	6	20	N.A
	Korba	12	19	81
	Raipur	14	40	N.A
Dadra & Nagar Haveli	Silvassa	8	20	N.A
Daman & Diu	Daman	8	20	N.A
Delhi	Delhi	5	59	237
	Panaji	9	14	67
	Marmagao	6	19	112
Goa	Vasco	7	20	84
	Curchorem	15	20	112

State	Cities	SO_2	NO_2	PM_{10}
	Codli	16	21	121
	Bicholim	10	18	119
	Amona	10	12	90
	Assanora	9	12	84
	Usgao	10	18	121
	Margao	9	17	67
	Tilamol	15	20	114
	Mapusa	7	9	82
	Sanguem	14	19	100
	Ponda	9	16	60
	Kundaim	9	16	63
	Ahmedabad	12	24	83
Gujarat	Anklesvar	18	27	99
	Jamnagar	12	25	101
	Rajkot	13	17	99
	Surat	16	26	97
	Vadodara	16	33	102
	Vapi	19	30	100
Haryana	Faridabad	12	38	184
	Hissar	6	8	111
	Yamunanagar	N.A	N.A	N.A
	Baddi	2	23	99
	Damtal	2	12	97
Himachal Pradesh	Kala Amb	2	16	165
	Nalagarh	2	23	89
	Parwanoo	2	8	79
	Paonta Sahib	2	15	153
	Una	N.A	N.A	69
	Sunder Nagar	2	11	94
J&K	Jammu	6	12	119
	Dhanbad	17	40	178
	Jamshedpur	37	49	149
Jharkhand	Jharia	17	40	212
	Ranchi	18	35	202
	Saraikela Kharsawan	39	51	160
	Sindri	17	40	170
	West Singhbhum	19	27	153
	Bangalore	14	28	121
	Gulburga	3	11	65
Karnataka	Hassan	5	17	36
	Hubli-Dharwad	5	14	77

State	Cities	SO_2	NO_2	PM_{10}
	Mandya	10	24	49
	Mangalore	6	7	31
	Mysore	11	23	56
	Devanagere	5	10	75
	Alappuzha	2	5	50
	Kochi	3	10	70
Kerala	Kollam	4	19	41
	Kottayam	6	16	56
	Kozhikode	2	8	56
	Malapuram	2	5	36
	Palakkad	3	7	37
	Pathanamthitta	2	15	23
	Thissur	2	15	73
	Wayanad	2	8	33
	Thiruvananthapuram	9	22	55
	Bhopal	3	21	173
	Dewas	18	23	92
Madhya Pradesh	Gwalior	13	27	329
	Indore	12	20	143
	Jabalpur	2	24	75
	Nagda	26	27	103
	Sagar	3	13	120
	Singrauli	24	25	64
	Ujjain	12	13	80
	Dombivali/Ambernath	52	87	114
	Amravati	11	13	100
Maharashtra	Aurangabad	9	32	80
	Badlapur	6	86	124
	Chandrapur	11	19	148
	Jalgaon	19	44	130
	Latur	8	20	117
	Lote	25	14	40
	Mumbai	5	20	117
	Nagpur	10	32	103
	Nashik	24	27	95
	Navi Mumbai	17	43	120
	Pune	22	45	92
	Sangli	11	40	80
	Solapur	17	35	83
	Thane	20	12	72
	Ulhasnagar	46	79	111

State	Cities	SO_2	NO_2	PM_{10}
	Jalna	9	30	109
	Akola	9	10	139
	Nanded	30	30	53
Meghalaya	Byrnihat	35	20	138
	Dawki	2	8	44
	Tura	2	5	52
Nagaland	Dimapur	2	7	90
	Angul	6	19	106
Orissa	Balasore	3	14	82
	Berhampur	2	18	80
	Bhubneshwar	2	18	81
	Cuttack	2	17	68
	Rayagada	3	22	54
	Rourkela	5	11	98
	Sambalpur	3	15	53
	Talcher	8	19	116
	Kalinga Nagar	3	9	52
	Amritsar	15	39	202
Punjab	Dera Bassi	9	28	129
	Pathankot/Dera Baba	7	12	68
	Gobindgarh	9	35	201
	Jalandhar	13	26	136
	Khanna	10	26	213
	Ludhiana	11	27	228
	Naya Nangal	7	19	89
	Patiala	5	13	62
	Batala	8	14	42
Puducherry	Puducherry	9	52	187
	Jaipur	6	24	189
	Jodhpur	8	32	156
Rajasthan	Jodhpur	6	31	155
	Kota	8	14	42
	Udaipur	9	52	187
	Chennai	12	21	57
	Coimbatore	3	27	68
Tamil Nadu	Madurai	14	30	48
	Salem	9	22	60
	Tuticorin	14	14	134
	Trichy	11	17	76
	Allahabad	4	32	317
	Anpara	17	31	134

State	Cities	SO_2	NO_2	PM_{10}
Uttar Pradesh	Bareily	12	24	231
	Gajraula	19	29	158
	Ghaziabad	30	34	248
	Jhansi	8	21	110
	Kanpur	8	34	215
	Khurja	25	25	168
	Lucknow	8	32	211
	Meerut	4	43	129
	Muradabad	13	23	165
	Noida	9	35	136
	Varanasi	18	21	138
	Unnao	10	32	98
	Saharanpur	11	29	186
	Raebareli	11	15	163
	Mathura	23	29	208
	Gorakpur	18	35	123
	Haldwani	N.A	N.A	137
Uttarakhand	Haridwar	28	32	149
	Kashipur	N.A	N.A	180
	Rudrapur	N.A	N.A	158
	Asansol	10	37	111
	Barrackpore	13	48	130
West Bengal	Durgapur	13	48	108
	Haldia	13	41	238
	Howrah	13	40	186
	Kolkata	12	70	135
	Raniganj	14	45	126
	South Suburban	8	59	119

Source: CPCB 2014

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