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Abstract

Air pollution causes some of the most serious long-term impacts on human health. Unlike other health problems, the diseases caused by air-pollution are likely to affect everyone exposed to polluted air. This paper makes an attempt to ascertain the economic burden of diseases related to air-pollution in urban areas. We define economic burden of illness in terms of health expenditure and loss of income due to illnesses caused by air pollution. It is observed that India has started experiencing a rapid growth of urban population in recent past. Although number of class 1 cities has increased from 25 in 1901 to 503 in 2011, it is the group of non-class I cities (class III, IV and V cities with less than 1, 00,000 population) that have increased considerably during this period. The data collected from air quality monitoring stations indicate that a large number of cities suffer from very unhealthy quality of air due to vehicular emissions and emissions from industries that are located in large numbers in the urban areas.

Incidentally, there was also a substantial increase in health expenditure of households for treatment of air pollution related diseases over the 10 years between 2004 and 2014. Using non-parametric regression analysis, we argue that the impact of air pollution related health disorders outweighs the impact of other health problems on income loss. This indicates how severe and serious air pollution can prove to be by taking toll not only on health but also the households' income in the urban areas of India within a short span of 10 years. The burden of air pollution related illness on loss of income reinforces the nexus between health and income poverty in urban areas, particularly among the socially weaker sections.

Keywords : Air-pollution, Sustainability, Health, Economic burden, Urban

JEL Classification : Q560, Q530, I150, I390, R110

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Burden of Diseases due to Air Pollution in Urban India

Amrita Ghatak[1], Debasish Nandy and Suddhasil Siddhanta[2]

1. Introduction

Urban areas are conceptualised as relations between material environment and location of collective life, between a specific territory and population. They are also considered as drivers of economic development, wealth and employment generation. Economic growth may lead to environmental pollution at the initial stage of development (Grossman and Krueger, 1995). In some contexts, fast growing low-income countries may not experience the increase in environmental pollution (Norton, 1998). Some studies also conclude that environmental quality is a "luxury good", hence, demand for it is expected to rise faster than income (Coursey, 1992). It is also found that high economic growth is correlated with improved environmental quality (Norton, 1998). However, despite having high rate of economic growth, air-pollution in India particularly in the urban areas has been alarmingly increasing in recent years. Air quality has failed to meet the health-based standards in many of the Indian cities[3] raising concerns over the quality and sustainability of life in urban areas.

Poor quality of air leads to growing burden on people's health (Soubbotina and Sheram, 2000). Globally, exposure[4] to outdoor air pollution is responsible for 2.9 million deaths per year (Global burden of diseases study, 2013). Air pollution causes some of the most serious long-term impacts on human health. Unlike other health problems, the diseases caused by air-pollution affect everyone exposed to the polluted air. This paper makes an attempt to ascertain the economic burden of diseases related to air-pollution in

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[3] http://www.cseindia.org/node/209

[4] Exposure is measured by levels of particles less than 2.5 microns in aerodynamic diameter.

urban areas. By economic burden of illness we mean the burden of health expenditure and loss of labour productivity as reflected in loss of income due to diseases that are caused by air pollution.

When we talk about urbanisation, the fundamental challenge is that there is no universal agreement on the definitions of "urban" and "city." Although researchers widely use terms such as "urban population" and "cities of over 100,000 people" there is no unique consensus about how large or dense a settlement needs to be in order to be designated as a city. Also, the characteristics of cities do not indicate any certain kinds of economic activity. Moreover, the border between a city and a village is not well-marked since the city is linked with villages through the urban outskirts of peripheries making it difficult to identify where precisely the urban area ends and the rural area begins.

Although there are new and innovative forms including maps of built-up areas derived from imagery and radar data from satellites used to identify cities or urban areas, this paper will consider the definition of urban agglomeration as provided by Census 2011[5] and will use the NSS data for urban areas. The rate of urbanisation will be indicated by number of people residing in urban areas according to Census figures. In order to draw the association between cities, air-pollution and health, the paper will consider NSS 60th and 71st round information on health and morbidity.

The next section (section 2) of this paper discusses the sources of data. In section 3 we will discuss the status and pattern of air pollution, urbanisation and economic growth of States and UTs in India. We will also make an attempt to examine the burden of air-pollution related diseases in urban areas in section 4 followed by concluding remarks in section 5.

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[5] An urban agglomeration is a continuous urban spread constituting a town and its adjoining outgrowths (OGs), or two or more physically contiguous towns together with or without outgrowths of such towns. An Urban Agglomeration must consist of at least a statutory town and its total population (i.e. all the constituents put together) should not be less than 20,000 as per the 2001 Census. In varying local conditions, there were similar other combinations which have been treated as urban agglomerations satisfying the basic condition of contiguity. Examples: Greater Mumbai UA, Delhi UA, etc. (Census, 2011).

2. Sources of data

There is no regular nation-wide survey undertaken to estimate the prevalence of air-pollution related health risks in urban areas particularly in industries and indoor or outdoor spaces. We have collected the data on air-quality index from 52 monitoring stations[6]. The data on air-quality index were collected five times in early morning (between 5 and 6 AM), morning (between 9 and 10 AM), afternoon (between 1 and 2 PM), evening (between 4 and 6 PM) and night (between 11 PM and 12 mid night) from each station for 7 days, and then average air-quality was calculated for each station/city. This will indicate the quality of outdoor air in those urban areas.

In order to estimate the number of persons suffering from specific illness in urban areas, we have relied on the unit level data from National Sample Survey (NSS) of 60th round (2004) and 71st round (2014) of surveys on Health and Morbidity. NSS data on morbidity is the only national level survey that can be used to discuss the ailments and the economic burden of diseases at the household level.

For the purpose of analysis, we have focused on the responses provided by the respondents to the query: 'whether ailing anytime during the last 15 days before the date of survey'. This includes cases of hospitalization, as well. We consider the information on self-reported morbidity conditions asking whether the respondent (hospitalized or not) fell sick in last 15 days prior to the date of survey, for the present analysis. It is known that self-reported illness suffers from "positional objectivity" bias (Sen, 2002) in assessing morbidity. However, it is relevant to understand the well-being through health, particularly, for the objectivity of decisions about beliefs and actions (Sen, 1993) and therefore it helps in understanding the cultural relativism in perceiving health.

Ailments that are normally associated with air-pollution[7], such as:(a) respiratory ailments (including ear/nose/throat ailments, tuberculosis and bronchial asthma), (b) eye ailments (including conjunctivitis, glaucoma and

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[6] http://aqicn.org/map/india/#@g/19.4387/62.9589/7z

[7] Refer http://www.environmentalpollutioncenters.org/air/diseases/ to identify the diseases related to air-pollution

cataract), (d) skin diseases, (e) neuro-behavioral disorders, and (f) fevers have been considered in this paper as diseases related to air pollution. Because of lack of detailed information on different types of cancers and cardio-vascular disorders, we could not include those diseases in the category of air-pollution related diseases.

The burden of air-pollution related diseases is indicated by the share of health expenditure to the household's total monthly expenditure and the share of income loss due to illness to the total household's monthly income, wherein income is surrogated by expenditure. The data have been analysed using cross tabulations and percentages and non-parametric regression technique.

3. Air pollution and urbanisation in India

Air pollution contributes, to a great extent, to the contamination of food and water, which makes in several cases the major route of pollutant intake (Thron, 1996). Absorption of pollutants normally occurs through gastrointestinal and respiratory tracts. A number of toxic substances can be found in the general blood circulation and deposit to different tissues. Elimination of substances occurs to a certain degree by excretion (Madden and Fowler, 2000).

Data on air quality index maps as collected from 52 monitoring stations show that on an average 36 cities/monitoring stations report unhealthy or hazardous air where as there are only 3 monitoring stati located in Tamil Nadu and West Bengal (Table 1) with good quality air. In order to examine the disease burden as reflected in health expenditure, we restrict our analyses to the urban areas in these 11 major States that have, to a great extent, unhealthy air quality.

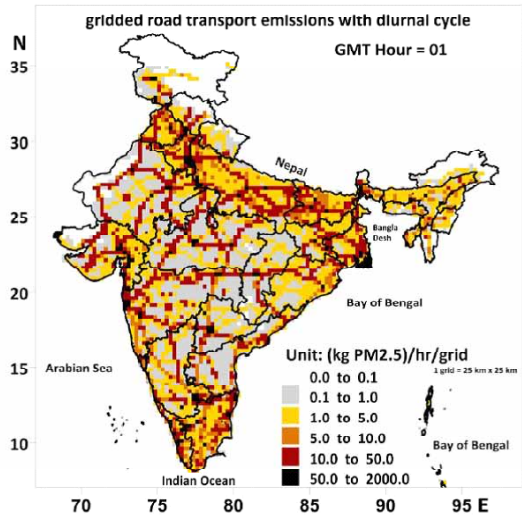
Table 1: Number of monitoring stations/cities by average quality of air based on air quality index collected from 52 monitoring stations in various States.

States	Number of monitoring stations/cities by quality of air					
	Hazardous	Very unhealthy	Unhealthy	Unhealthy for sensitive people	Moderate	Good
Andhra Pradesh	–	–	–	–	2	–
Telangana	–	–	1	–	–	–
Bihar	–	–	–	2	–	–
Delhi	1	1	7	–	1	–
Haryana	–	–	1	–	1	–
Karnataka	–	–	1	1	3	–
Maharashtra	–	1	4	4	5	–
Rajasthan	–	–	2	–	1	–
Tamil Nadu	–	–	1	1	–	2
UttarPradesh	3	1	2	1	–	–
West Bengal	–	–	–	1	–	1

Source: http://aqicn.org/map/india/#@g/19.4387/62.9589/7z

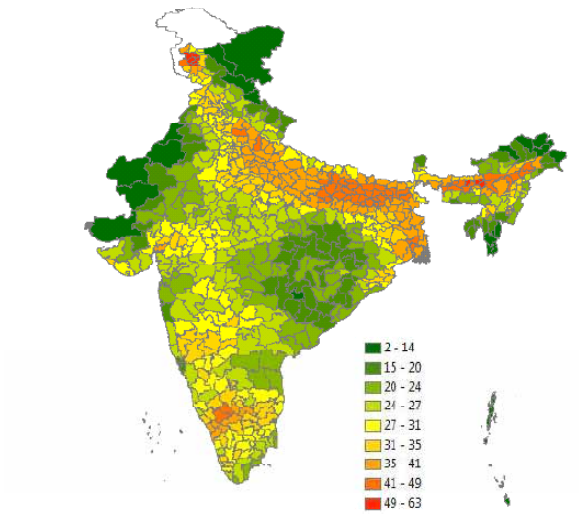
The air quality is influenced by vehicular emission, industrial emission and domestic emission. Map 1 shows that the intensity of road-transport emissions are concentrated in big cities, such as Delhi, Ahmedabad, Bengaluru, Mumbai, Kolkata, Hyderabad, Chennai, and Pune. Map 2 shows that the share of households' fuel consumption to outdoor PM2.5 pollution is very high and forms a contiguous belt in Uttar Pradesh, Bihar, West Bengal and parts of North-eastern States, Karnataka and Kerala. It indicates the use of unclean fuel or fossil fuel to a large extent by the households in those regions. However, use of unclean fuel is still a major concern in rural areas in which only around 18 percent of the households use clean fuel in 2014 (NSS, 71st round unit level data on health and morbidity). In the same year, around 75 percent households in the urban areas are found to use the clean source of fuel such as LPG, Electricity and Gobar gas (NSS 71st round data on health and morbidity).

Map 1: Road Transport Emissions.



Source: Sources of air pollution in India, Goel, *et al*. 2014.

Map 2: Share of households' fuel consumption to outdoor PM2.5 pollution.



Source: Sources of air pollution in India, Goel, *et al*. 2014.

Vehicular emission in cities and industrial emissions in their peripheries are the major concern for air pollution in the urban areas. Urban hinterland and slums also suffer from problems of using fossil fuel for cooking purpose. The concentration of vehicular emissions in cities combined with the emission from fuels used at the households pose serious threat to the health of urban people. The health impacts of outdoor air pollution include as ischemic heart diseases which can lead to heart attacks, cerebrovascular diseases which can lead to strokes, chronic obstructive pulmonary diseases, lower respiratory infections, and cancers (in trachea, lungs, and bronchitis) (Goel, *et al*, 2014) .

Evidently, India has started experiencing a rapid growth of urban population in recent past. The proportion of population residing in urban areas had increased from 11% in 1901 to over 31% in 2011 (Table 2). More than the increase in urban population over a century, what is interesting to note is that this increase has experienced boom in some specific periods. For instance, the rate of urbanization was slow till 1941. But post-independence, there was a sudden leap in the urban population in 1951, and this sudden increase was further observed in 1981 and then again recently in 2011. Although the number of class 1 cities had increased from 25 in 1901 to 503 in 2011, it is the non-class I cities (all cities with less than 1,00,000 population) that have increased to a great extent during this period (Table 3). Particularly there are a large number of urban settlements that fall under the categories of class III, IV and V cities (Table 3). This indicates a rapid growth of non-metropolitan cities and urban hinterland in the last decade.

Table 2: Trend of Urbanisation in India (1901 to 2011 Census).

Census Year	Total Population (in million)	Urban Population (in million)	Urban Population (%)	Decadal Urban Growth Rate
1901	238.40	25.85	10.85	NA
1911	252.09	25.95	10.29	0.36
1921	251.32	28.09	11.18	8.26
1931	278.98	33.46	11.99	19.12
1941	318.66	44.16	13.86	31.98
1951	361.09	62.44	17.29	41.40
1961	439.23	78.94	17.97	26.41
1971	548.16	109.11	19.91	38.23
1981	683.33	159.46	23.34	46.14
1991	846.30	217.61	25.71	36.47
2001	1028.61	286.12	27.82	31.48
2011	1210.57	377.11	31.15	31.80

Notes: Abbr: NA: Not Applicable

1. Includes the interpolated population of Assam for 1981; the total population is 18041248 and urban population is 1782376;
2. Includes the projected population of Jammu & Kashmir for 1991; the total population is 7718700 and urban population is 1839400.

Source: National Institute of Urban Affairs & Agricultural Research & Office of the Registrar General and Census Commissioner, India.

Table 3: Number of towns in different classes in India from 1901 to 2011.

Year	Class/Category of Cities/Towns						
	All Classes	Class-I (100000 & above)	Class-II (50000-99999)	Class-III (20000-49999)	Class-IV (1000-19999)	Class-V (5000-9999)	Class-VI (Less than 5000)
1901	1917	25	44	144	427	771	503
1911	1909	26	38	158	388	750	546
1921	2047	29	49	172	395	773	626
1931	2219	31	59	218	479	849	580
1941	2424	49	88	273	554	979	478
1951	3060	76	111	374	675	1195	629
1961	2700	107	139	518	820	848	268
1971	3126	151	219	652	988	820	296
1981*	3949	226	325	883	1247	920	348
1991**	4615	322	421	1161	1451	973	287
2001	5161	441	496	1388	1561	1041	234
2011	7935	503	607	1892	2232	2190	511

Note: *Excludes figures for Assam where census of 1981 was not held.

** Excludes figures of Jammu & Kashmir where census of 1991 was not conducted.

Source: Ministry of Urban Employment & Poverty Alleviation & Office of the Registrar General and Census Commissioner, India.

Almost 70 percent of GDP is generated in the urban areas in India. In Delhi 96% of its GDP comes from urban areas. Similarly around 85% of states' GDPs in industrialised States such as Gujarat, Maharashtra, Chhattisgarh and Karnataka come from urban areas. Among southern States, Andhra Pradesh (58%) and Tamil Nadu (75%) experience large shares of GDP originated from urban areas (Mitra, 2013).

Table 4 : Net State Domestic Product (NSDP) between 2009-10 and 2013-14, number of towns and percentage of urban population by States/UTs.

States/UTs	Change in NSDP between 2009-10 and 2013-14	No. of towns/urban agglomerations (2011)	Population in urban areas (in %) [2011]
Bihar	1.128	199	10.46
Sikkim	1.039	9	11.07
Rajasthan	0.991	297	23.39
Mizoram	0.972	23	33.04
Madhya Pradesh	0.925	476	26.46
Telangana	0.916	---	---
Jammu & Kashmir	0.852	122	24.81
Chhattisgarh	0.843	182	20.09
Arunachal Pradesh	0.836	27	20.75
Tripura	0.833	42	17.06
Delhi	0.818	113	93.18
Karnataka	0.815	348	33.99
Tamil Nadu	0.795	1097	44.04
Maharashtra	0.771	535	42.43
West Bengal	0.770	909	27.97
Gujarat	0.756	348	37.36
Meghalaya	0.750	22	19.58
Uttarakhand	0.748	115	25.67
Haryana	0.735	154	28.92
Jharkhand	0.726	228	22.24
Puducherry	0.721	10	66.57
Kerala	0.704	520	25.96
Manipur	0.704	51	26.58
Goa	0.687	70	49.76
Nagaland	0.681	26	17.23
Odisha	0.678	223	14.99
Andhra Pradesh	0.666	353	27.30
Himachal Pradesh	0.661	59	9.80
Uttar Pradesh	0.641	915	20.88
Assam	0.638	214	12.90
Chandigarh	0.619	6	89.77
Punjab	0.591	217	33.92

Note: NSDPs are taken in constant prices with base in 2004-05.

Source: Authors' calculation based on data from Economic and Political Weekly Research Foundation, Office of registrar general and census commissioner, Govt. of India, and National Institute of Urban Affairs, New Delhi.

Except few major States, like Bihar, Rajasthan and Punjab in States and/or Union Territories such as Delhi, Chandigarh, Haryana, Gujarat, Karnataka, Tamil Nadu, Maharashtra, West Bengal, Goa and Puducherry, the high growth during the 5-year-period from 2009 to 2014 has been associated with large share of people (30% or above) in the urban areas (Table 4). Fast-growing States like Bihar, Rajasthan, Madhya Pradesh, Telangana and Chhattisgarh exhibit potential for a rapid growth in urban population in near future.

These urban areas especially the outskirts of big cities and small towns are also the regions wherein industrial clusters are located. Micro and small manufacturing enterprises have a sizeable share in their contribution to Gross Domestic Product in India. Majority of them are in the informal/unorganized sector, where they stand for innovation, entrepreneurship, incubating and nurturing new ideas and play an important role in the livelihoods of millions but also recognised as a sector where occupational health and safety is given little importance. While many jobs in the manufacturing sector pave the way for both communicable and non-communicable diseases (NCDS), there has not been a systematic approach to bring out the relationship between work environment and NCDS which are rising globally and India is no exception to that. Globally, the Years of life lost (YLL) due to non-communicable diseases (NCDS) increased from 38 per cent in 2000 to 42 per cent in 2012. An individual suffering from NCDS is highly susceptible to infectious diseases as well. This is a case of concern, as some of the non-communicable diseases are linked to the working environment, like Asthma, cardiovascular diseases (CVD), chronic Obstructive Pulmonary Disease (COPD), congenital conditions, diabetes, diseases of the digestive system (e.g., peptic ulcers), eye conditions, genitourinary conditions (prostate disorders, nephritis), neuro-psychiatric conditions (mental disorders, epilepsy, Alzheimer's), skin and musculoskeletal conditions (e.g., arthritis),skin diseases, cardio vascular diseases, cancer, depression etc (Lalitha and Ghatak, 2015).

Although some sectors that include manufacturing industries like textiles, paper and paper products, metal products, chemical products, machine tools, transport equipment; electricity and gas and sectors like construction sector, other types of mining and quarrying and fishing are considered to be associated with the health and safety concerns of the workers. They contribute substantially to the economic growth of each State. For instance, 27% of total gross state domestic product in Haryana is contributed by

fishing, mining-quarrying, manufacturing, construction and electricity-gas sectors in 2014-15. During the same year, these sectors contributed 21.4%, 30.3%, 28.63%, 26.56%, 27.21% and 19.57% to the GSDPs of West Bengal, Goa, Tamil Nadu, Karnataka, Punjab and Andhra Pradesh, respectively. All these sectors are known to emit pollutants to the air causing various chronic and acute health problems.

Air pollution contributes to the contamination of food and water affecting the human respiratory system, cardio-vascular system, nervous system, urinary system and digestive system (Thron, 1996). A number of air pollutants are released from industrial facilities and other activities and may cause adverse effects on human health and the environment. By definition, an air pollutant is any substance which may harm humans, animals, vegetation or material (Kampa and Castanas, 2008). Although there are varieties of air-pollutants that differ in their chemical composition, reaction properties, emission, persistence in the environment, ability to be transported in long or short distances and their eventual impacts on human and/or animal health, there are some similarities based on which the air-pollutants can be grouped into four categories: (1) Gaseous pollutants (e.g. SO2, NOx, CO, ozone, Volatile Organic Compounds); (2) Persistent organic pollutants (e.g. dioxins); (3) Heavy metals (e.g. lead, mercury) and (4) Particulate Matter.

Gaseous pollutants are results of combustion of fossil fuels. Road transport is a major source of this. Even though the majority of gaseous pollutants are inhaled and mainly affect the respiratory system they can also induce hematological problems (CO, benzene) and cancer (Kampa and Castanas, 2008). Similarly, Major sources of particulate pollution are factories, power plants, refuse incinerators, motor vehicles, construction activity, fires and natural windblown dust. According to various rounds of information as available with the Annual Survey of Industries, factories are located largely in the urban areas and provide employment to a large proportion of work force (Table 5).

Table 5: Selected Principal Characteristics of Factories by Rural - Urban Break from 2009-10 to 2013-14.

Year	Percentage of factories		Percentage of workers		Percentage of persons engaged		Percentage of outputs	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
2009-10	37.42	62.58	42.00	58.00	40.81	59.19	45.58	54.42
2010-11	36.87	63.13	42.88	57.12	42.05	57.95	46.49	53.51
2011-12	37.21	62.79	43.56	56.44	42.58	57.42	47.49	52.51
2012-13	38.34	61.66	43.95	56.05	43.27	56.73	46.74	53.26
2013-14	38.44	61.56	43.88	56.12	43.31	56.69	49.25	50.75

Source: Authors' calculations from various rounds of ASI data

4. Burden of air-pollution related diseases in urban areas

As explained in the previous sections, diseases related to air pollution include: (a) respiratory ailments (including ear/nose/throat ailments, tuberculosis and bronchial asthma), (b) eye ailments (including conjunctivitis, glaucoma and cataract), (c) skin diseases (d) neuro-behavioral disorders and (e) fevers. Although NSS data provide information on cardio-vascular diseases and cancers/tumors, the types of such diseases are not specified. Therefore it is not possible to identify cancers and cardio-vascular problems as an outcome of air-pollution.

The expenditure incurred for treatment and the income lost due to ailments at the household level are two alleyways through which economic burden of those above mentioned air-pollution related diseases are discussed in this paper. While expenditure for treatment indicates the direct economic burden of illness, loss of income shows it indirectly. The loss of income due to ailment also indicates loss of labour productivity due to health reasons.

According to the nutrition-based efficiency wage hypothesis (Leibenste in, 1957), it is argued that in poor economies where wages determine workers' consumption level, the amount of workers' effort would depend positively on their nutrition and health status and thus on wages. Health is found to be an important factor that determines individual's economic as well as non-economic well-being (Strauss, 1986; Sahn and Alderman, 1988), though the impact of illness and health impairments on labour market and social welfare are complex. Some studies (Dohrenwend, 1973; Pearlin, 1989; House and Williams, 2000) indicate that the individuals belonging to lower socio-

economic status are likely to suffer more from physical, psychological and social stresses than their higher status counter parts and it accounts for the increased incidence of morbidity and mortality among them. The impact of physical stress reflected in increased morbidity is not well examined through the resultant income loss. A few studies (Mclntyre, et al., 2006; Ettner, 1995) highlight the link between health and income, focusing on the economic consequences at the household level. At the household level, these have impacts on direct costs, viz. medical treatment and related financial costs, indirect costs, viz. productive time losses due to illness resulting in income loss vis-à-vis household responses (Mclntyre, et al., 2006). There is growing evidence of households being pushed into poverty when they face substantial medical expenses, particularly when combined with a loss of household income due to ill-health. For the individuals, whose earnings largely depend on the manual labour, income and wages do not carry different meanings by and large.

Both the NSSO 60th round (2004) and 71st round unit level data (2014) on health and morbidity provide the information on loss of income due to ailment at the household level. The loss of household's income due to ailment indicates the loss of wages or loss of labour productivity, particularly in an economy where labour is mainly manual and informal in nature (Ghatak and Madheswaran, 2011). A large chuck of population in the urban areas is engaged in the rapid growing industries such as manufacturing, electricity-gas, mining and quarrying, and construction. These industries often operate as unorganized enterprises and employ a large number of workers as casual or contractual labourers.

Cities are known to provide with better work opportunities compared to the State average. The work participation rate is also likely to be higher in cities compared to other smaller urban settlements (Mitra, 2013). Because large cities provide the opportunity of highly remunerative or productive labour contracts, the loss of income during the episodes of illness is also high in larger cities compared to other areas.

We have considered urban areas of 11 States – Andhra Pradesh, Telangana, Bihar, Delhi, Haryana, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal – for this analysis of economic burden of air-pollution related diseases. Except in Andhra Pradesh,urban areas in all other States have experienced substantial increases in the percentage of

people suffering from diseases that are related to air pollution between 2004 and 2014. Although percentage of people using clean fuel for cooking purposes has increased over the decade from 2004 to 2014 the proportion of ailing persons suffering from air pollution related diseases has also increased (Table 6). This indicates that the outdoor air-pollution caused by vehicular and industrial emissions are major factors in causing various health problems.

Table 6: Persons suffering from air-pollution related diseases and percentage of people using clean sources of fuel for cooking purpose in selected urban areas of selected States and all India: NSS (2004) and NSS (2014).

State	NSS 2004		NSS 2014	
	(%) of people suffering from air-pollution related diseases	(%) of people using clean source of fuel	(%) of people suffering from air-pollution related diseases	(%) of people using clean source of fuel
Andhra Pradesh	29.54	64.07	20.04	86.26
Telangana	29.54	64.07	35.64	91.08
Bihar	49.99	53.37	51.22	55.13
Delhi	28.51	87.05	58.66	97.68
Haryana	36.43	73.9	51.97	84.94
Karnataka	28.13	56.74	37.34	80.02
Maharashtra	34.02	71.19	46.93	84.68
Rajasthan	38.84	64.33	44.12	71.33
Tamil Nadu	35.63	55.09	28.20	82.96
Uttar Pradesh	45.97	51.55	46.38	69.27
West Bengal	22.25	48.00	29.73	56.5
All India (Urban)	37.20	60.26	40.45	74.9
All India (Total)	43.1	21.44	45.00	34.87

Note: Figures are weighted according to NSS formulae.
Source: Authors' calculation based on NSS 60th and 71st rounds unit level data.

The burden of health expenditure is measured as a share of monthly household income proxied by expenditure. Whereas the average number of days spent on restricted activities during the episode of air-pollution related ailments has declined slightly from 2004 to 2014, the average expenditure incurred for treatment of such diseases has increased to a great extent (Table 7).

Table 7: Number of days spent in restricted activity, burden of health expenditure and burden of income loss due to ailments related to air pollution in urban areas of selected States and India.

State (Urban)	2004				2014			
	Average number of days on restricted activities (15 days reference period)	Average of expenditure incurred due to air-pollution related diseases	burden of expenditure (hospitali-sation)	Average of %of income lost due to ailment related to air-pollution	Average number of days on restricted activities (15 days reference period)	Average of expenditure incurred due to air-pollution related diseases	burden of expenditure (hospitali-sation)	Average of %of income lost due to ailment related to air-pollution
Andhra Pradesh	3.81	34.58	0.89	4.88	1.87	65895.99	356.94	2.29
Telangana	3.81	34.58		4.88	2.05	21091.67	219.32	3.89
Bihar	4.34	27.82	1.04	14.00	1.12	16853.65	174.19	0.87
Delhi	6.55	-	-	20.05	2.31	18384.13	123.24	12.71
Haryana	3.83	23.00	0.25	5.92	2.10	34150.93	276.77	8.66
Karnataka	4.17	20.00	0.67	2.52	1.74	15373.77	157.58	3.71
Maharashtra	3.24	24.07	0.36	3.30	3.48	15486.36	160.07	10.83
Rajasthan	4.99	21.80	1.51	2.44	4.27	12268.64	90.55	4.77
Tamil Nadu	4.13	25.07	0.98	2.01	1.31	17442.61	166.11	2.44
Uttar Pradesh	5.41	77.31	3.17	8.23	2.08	12447.19	127.19	7.16
West Bengal	5.45	25.23	0.82	5.23	2.15	21732.64	228.02	2.40
All India (Urban)	4.29	37.18	1.42	8.05	2.37	19139.44	167.12	5.06
All India (Total)	4.69	59.23	2.60	14.68	2.40	14267.59	169.16	4.96

Note: Figures are weighted according to NSS formulae.
Source: Authors' calculation based on NSS 60th and 71st rounds unit level data.

As a result, the burden of health expenditure at the households for treatment of air pollution related diseases has also been very high in 2014. This huge amount of health expenditure may be associated with the low utilisation of government healthcare facilities. The use of government health care facilities in urban areas has gone down from 20 percent in 2004 to 6.9 percent in 2014. The reasons for not accessing the government health care facilities could range from accessibility issue or non- availability of doctors to lack of diagnostic facilities and medicines. It is known, that the health care costs where 90 per cent are private expenditures may cause economic distress leading to vulnerable situation for the poor in cities. Unlike burden of health expenditure, the burden of income loss due to air pollution related diseases has declined in many States such as West Bengal, Uttar Pradesh, Delhi, Andhra Pradesh and Bihar.

The sample shows that the burden of income loss due to illness is concentrated in zero and with fewer observations at the higher values. In order to understand the conditional median and other quantiles of the response variable which is the burden of income loss due to ailment, a non-parametric quantile regression technique is followed. Since the data are censored at zero, the conditional mean may not be identifiable without additional distributional assumptions although the conditional quantile is identifiable. Background characteristics such as social group and age are included as control variables in order to address the possibility of unforeseen discrimination in the labour market that may have bearing with the burden of income loss. Using information on usual activity status we have identified activities that are often informal and/or casual in nature. Therefore one variable representing participation in informal sector works or self-employment is included in the analysis. The household amenities index, which is constructed using principal component analysis of household level information such as type of house-structure, availability of latrine, drainage, and accessibility to safe drinking water and clean source of energy for cooking purpose, has been incorporated in the model. As far as information on health is concerned, we have considered the number of sick-days during which the respondent has not been freely mobile and therefore restricted from daily routine activities.

The regression results are reported in Tables 8 and 9. Both the models represent the cases for Urban India. In the first model we have reported the case for burden of income loss due to ailments, whereas in the second model we report the case for burden of income loss due to air-pollution related ailments. Both the models for 2004 are presented in Table 8 and the same models for 2014 are presented in Table 9.

It is interesting to observe that number of restricted days due to sickness increases the burden of income loss due to health reasons and the extent of its impact increases in the upper quantiles of the burden (Tables 8a,b and 9a,b). Number of days when the activities are restricted due to sickness directly indicates the loss of labour productivity.

Table 8 (a,b): Regression results for burden of income loss due to ailment and burden of income loss due to air-pollution related ailments: All India Urban, NSS (2004).

8 (a). Model 1: For all ailments in urban India, 2004

Dependent variable	Burden of income loss due to ailment			
Independent variables	0.7	0.8	0.9	0.99
	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)
Number of restricted days	0.27*** (0.06)	0.91*** (0.08)	1.98*** (0.13)	25.68* (19.51)
Amenities index	-0.78** (0.31)	-1.12*** (0.43)	-1.42** (0.72)	-0.81 (1.25)
ST	3.33* (1.99)	1.56 (2.76)	4.78 (4.58)	49.90*** (7079.14)
SC	0.00 (1.12)	0.00 (1.56)	0.52 (2.58)	95.66 (3990.33)
OBC	0.00 (0.76)	0.00 (1.06)	0.00 (1.76)	-7.50 (2715.47)
age	0.00 (0.06)	0.00 (0.08)	0.00 (0.13)	0.32 (200.81)
Age squared	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (2.37)
Whether avails govt healthcare facilities	0.00 (0.77)	0.00 (1.07)	0.00 (1.77)	44.95 (2733.44)
Whether casual labour/wage worker	9.09*** (0.78)	12.49*** (1.09)	18.99*** (1.81)	53.08* (2792.36)
Constant	1.61[w] (1.18)	2.32 (1.64)[w]	2.95 (2.73)	9.19 (4213.98)
Number of observations	3113	3113	3113	3113
pseudo R^2	0.003	0.004	0.005	0.3838

Note: Standard errors are in parentheses. ***, ** and * indicate levels of significance at less than 1%, less than 5% and less than 10% respectively. [w]indicates weak significance at less than 20 per cent.

The increase in number of restricted days will make individuals to lose the labour days or lose the opportunity of working in highly remunerative tasks, thereby reducing their wages or income. While this variable is found to be a significant determinant of burden of income loss in its

various quantile groups for overall ailments and ailments caused by air pollution both in 2004 and 2014, the extent of its impact various over the decade.

8 (b). Model 2: For air pollution related ailments in urban India, 2004

Dependent variable	**Burden of income loss due to ailment**				
Independent variables	0.6	0.7	0.8	0.9	0.99
	Coeff (Stderror)	Coeff (Stderror)	Coeff (Stderror)	Coeff (Stderror)	Coeff Stderror
Number of restricted days	0.14** (0.06)	0.65*** (0.08)	1.09*** (0.12)	1.94*** (0.24)	7.00*** (2.00)
Amenities index	-0.32 (0.65)	-0.13 (0.92)	-1.41* (1.36)	0.00 (2.75)	0.00 (9.29)
ST	2.61* (1.54)	1.92[w] (2.00)	1.58 (3.20)	3.02 (6.47)	29.80*** (53.27)
SC	0.05 (0.96)	0.00 (1.36)	0.39 (2.01)	0.93 (4.05)	17.84*** (33.62)
OBC	-0.05 (0.69)	0.00 (0.98)	0.00 (1.44)	0.06 (2.91)	-9.79 (24.07)
age	0.01 (0.05)	0.00 (0.07)	0.00 (0.10)	0.03 (0.21)	0.66 (1.74)
Age squared	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.02)
Whether avails govt. healthcare facilities	0.02 (0.70)	0.00 (0.99)	0.00 (1.47)	-0.03 (2.96)	1.43 (24.30)
Whether casual labour/wage worker	7.22*** (0.75)	8.30*** (1.06)	10.59*** (1.57)	15.70*** (3.17)	26.31[w] (25.76)
Constant	0.19 (0.97)	0.13 (1.38)	1.41 (2.03)	2.57 (4.09)	9.79 (32.19)
Number of observations	1090	1090	1090	1090.00	1090.00
pseudo R^2	0.002	0.0032	0.004	0.0039	0.5142

Note: Standard errors are in parentheses. ***, ** and * indicate levels of significance at less than 1%, less than 5% and less than 10% respectively. [w]indicates weak significance at less than 20 per cent.

Table 9 (a,b): Regression results for burden of income loss due to ailment and burden of income loss due to air-pollution related ailments: All India Urban, NSS (2014).

9 (a). Model 1: For all ailments in urban India, 2014

Dependent variable	**Burden of income loss due to ailment**					
Independent variables	0.5	0.6	0.7	0.8	0.9	0.99
	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)	Coeff Std error
Number of restricted days	0.11*** (0.01)	1.00*** (0.02)	1.96*** (0.03)	3.33*** (0.03)	5.67*** (0.07)	23.40*** (0.84)
Amenities index	0.00 (0.07)	0.00 (0.11)	0.00 (0.13)	0.00 (0.13)	-0.15 (0.33)	-0.81 (4.31)
ST	0.00 (0.34)	1.00* (0.51)	4.08*** (0.64)	5.83*** (0.62)	14.18*** (1.62)	30.85* (20.87)
SC	0.00 (0.21)	0.00 (0.33)	0.00 (0.41)	0.00 (0.40)	0.61 (1.04)	3.35 (13.37)
OBC	0.00 (0.15)	0.00 (0.24)	0.00 (0.29)	0.00 (0.29)	1.21* (0.74)	-8.40 (9.58)
age	0.00 (0.01)	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)	-0.02 (0.05)	0.22 (0.66)
Age squared	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)
Whether avails govt. healthcare facilities	0.00 (0.16)	0.00 (0.24)	0.00 (0.30)	0.00 (0.29)	1.97** (0.76)	23.83** (9.84)
Whether casual labour/wage worker	0.00 (0.20)	0.00 (0.30)	0.00 (0.38)	0.00 (0.37)	0.10 (0.96)	11.07 (12.37)
Constant	0.00 (0.21)	0.00 (0.32)	0.00 (0.40)	0.00 (0.39)	1.36[w] (1.01)	31.99* (12.98)
Number of observations	25254	25254	25254	25254	25254	25254
pseudo R^2	0.003	0.033	0.101	0.17	0.22	0.31

Note: Standard errors are in parentheses. ***, ** and * indicate levels of significance at less than 1%, less than 5% and less than 10% respectively. [w]indicates weak significance at less than 20 per cent.

9 (b). Model 2: For air pollution related ailments in urban India, 2014

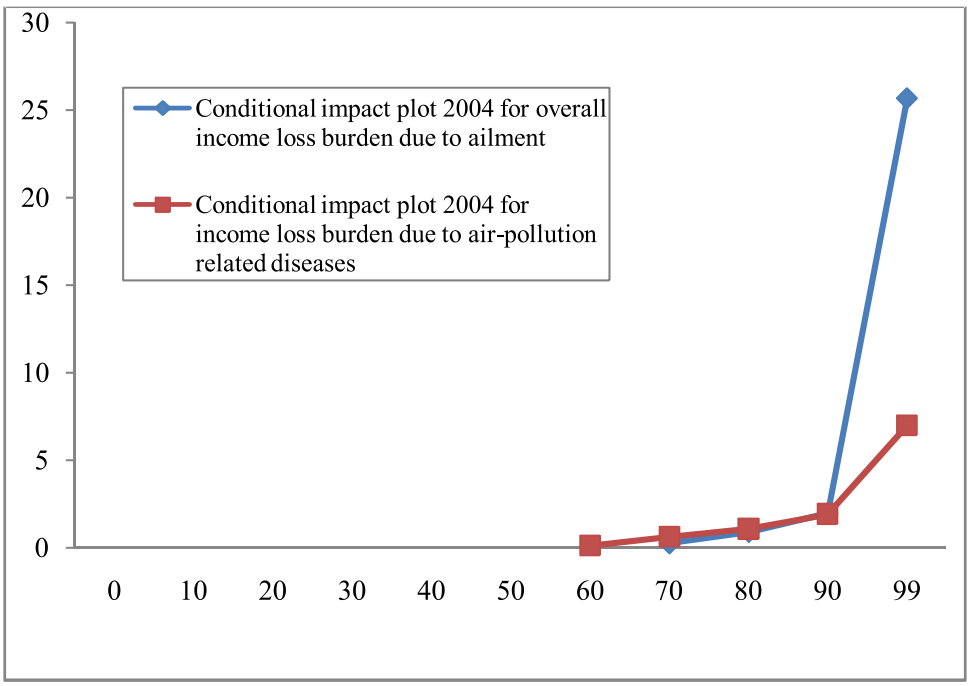
Dependent variable	**Burden of income loss due to ailment**				
Independent variables	0.6	0.7	0.8	0.9	0.99
	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)	Coeff (Std error)
Number of restricted days	0.67*** (0.03)	1.78*** (0.04)	2.68*** (0.06)	4.70*** (0.11)	24.46*** (0.80)
Amenities index	0.00 (0.11)	0.00 (0.15)	0.00 (0.23)	0.30 (0.38)	2.57 (2.90)
ST	3.50*** (0.51)	4.78*** (0.73)	6.41*** (1.10)	15.22*** (1.80)	-7.38 (13.63)
SC	0.00 (0.35)	0.00 (0.50)	1.32* (0.76)	4.55*** (1.24)	19.23** (9.42)
OBC	0.00 (0.25)	0.00 (0.36)	0.00 (0.55)	0.65 (0.90)	3.52 (6.80)
age	0.00 (0.02)	0.00 (0.02)	0.00 (0.04)	0.02 (0.06)	0.00 (0.46)
Age squared	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)
Whether avails govt. healthcare facilities	0.00 (0.28)	0.44[w] (0.39)	2.67*** (0.60)	8.53*** (0.97)	15.11** (7.37)
Whether casual labour/wage worker	0.00 (0.32)	0.61[w] (0.45)	1.89*** (0.69)	1.52[w] (1.13)	13.68* (8.53)
Constant	0.00 (0.32)	0.00 (0.46)	0.00 (0.70)	0.38 (1.15)	13.29[w] (8.67)
Number of observations	8472	8472	8472	8472	8472
pseudo R^2	0.025	0.086	0.131	0.185	0.315

Note: Standard errors are in parentheses. ***, ** and * indicate levels of significance at less than 1%, less than 5% and less than 10% respectively. [w]indicates weak significance at less than 20 per cent.

In order to compare the impact of overall illness and pollution related illness on income in urban India, we have done conditional impact analyses (Figures 1, 2, 3 and 4) of number of restricted days due to illness. Evidently in 2004 the impact of air-pollution related illness on income loss started early from 60 percentile of the distribution of burden of income loss, whereas the same impact for any other illness was found to have significant impact from 70 percentile of this distribution. However, at the higher percentile of the burden of income loss overall illness was found to have

much stronger impact on loss of income compared to that of the air pollution related diseases in 2004 (Figure 1). Over a period of 10 years between 2004 and 2014 the impact of illness on income loss has changed substantially with statistical significance.

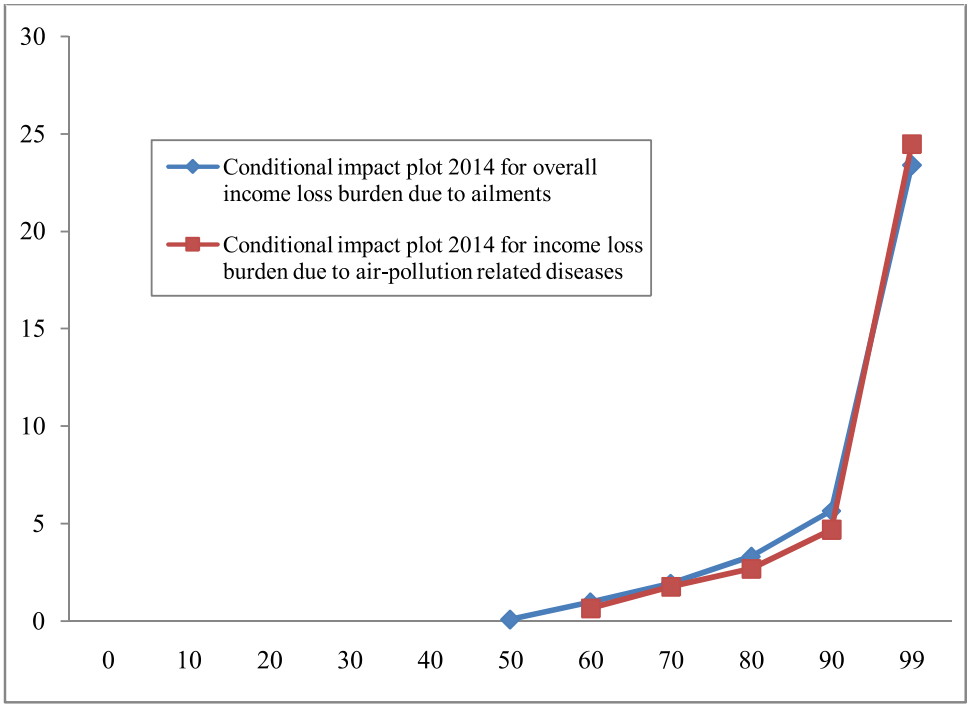
Figure 1: Conditional impact of number of restricted days on burden of income loss in urban India in 2004: Overall illness by illness due to air pollution.



Source: From regression results in Table 8a and 8b.

In 2014 the overall health burden on income starts from 50 percentile of the distribution of loss of income which is slightly earlier than those illnesses related to air pollution. However, the extent of impact of air-pollution on health and loss of income has become as high as that of overall impact of health on income loss in the urban areas (Figure 2). Evidently at the highest percentile of the distribution of income loss impact of air pollution related health disorders outweighs the impact of other health problems on income loss (Figure 2). This indicates how severe and serious air pollution proved to be by taking toll not only on health but also the households' income in the urban areas of India within a short span of 10 years.

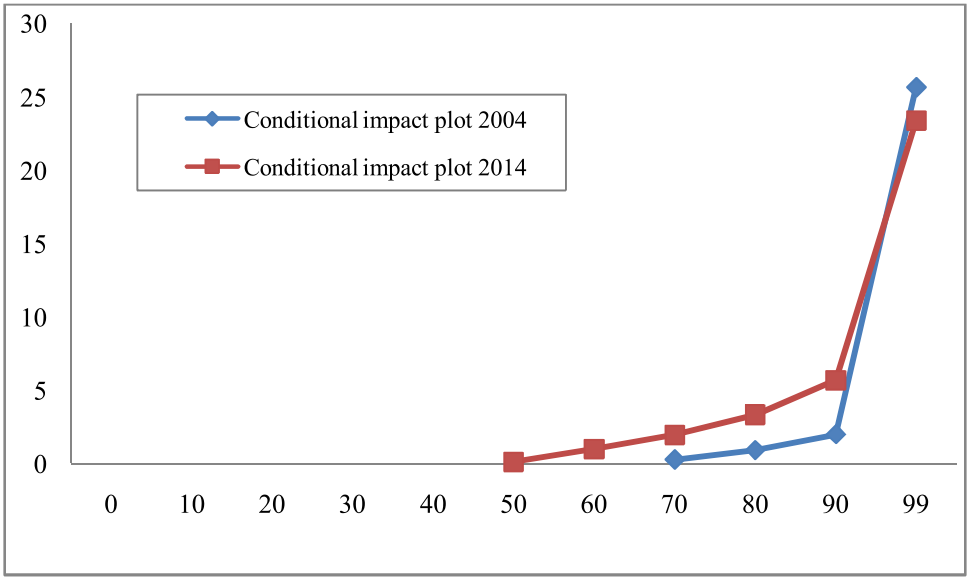
Figure 2: Conditional impact of number of restricted days on burden of income loss in urban India in 2014: Overall illness by illness due to air pollution.



Source: From regression results in Tables 9a and 9b.

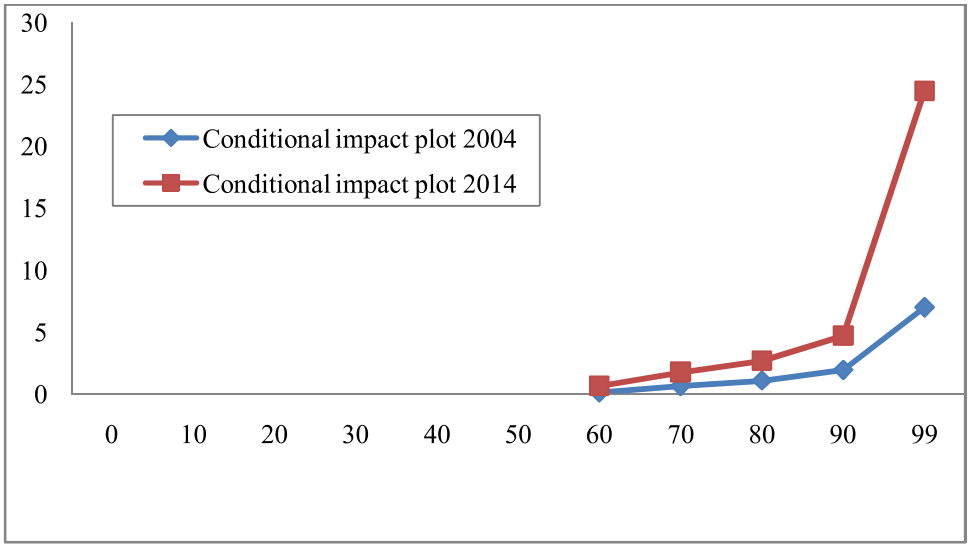
Whereas the extent of overall impact of illness on income loss continues to be the same as in 2004, it is important to note that the health burden of illness on income in urban areas now starts early at the 50 percentile of the distribution of income loss (Figure 3). On the contrary, the air-pollution related health problems still start having significant negative impact on households' income at the 50 percentile of the distribution of income loss. But the extent of this impact has gone up significantly in 2014 (Figure 4).

Figure 3: Conditional impact of number of restricted days on income loss burden due to ailments in Urban India: 2004 *vs* 2014.



Source: From regression results in Tables 8a and 9a.

Figure 4: Conditional impact of number of restricted days on income loss burden due to air-pollution related ailments in Urban India: 2004 *vs* 2014.



Source: From regression results in Tables 8b and 9b.

Those who suffer from air-pollution related diseases seem to suffer more from the income loss compared to those suffering from any other ailments in urban areas. It is important to remember here that due to limitations in NSS data we could not identify and include cancers and cardio-vascular diseases that are directly caused by prolonged inhalation of polluted air. Had we been able to include those major diseases, the impact of illness due to air pollution on income loss would have been much stronger and catastrophic in the urban areas.

The nature of employment being informal and manual further reinforces the linkages between health and income in urban areas to a large extent. With the current NSS data set in 2014 and after several years of NHM it is important to observe that health and poverty still exhibit nexus particularly among STs, SCs and those who work as casual or informal workers. The poor public health scenario combined with the safety and health issues at the unorganized industries further magnifies the burden of air pollution related diseases in urban areas. The explanation remains with the demographic change in past decade. The increase in working age population including both young workers (15-34 years) and relatively old workers (35 to 65 years) combined with the other factors such as rapid increase of informal industries including manufacturing, mining, construction and electricity and gas may explain the vulnerability of labour force in terms of incurring loss of productivity due to illness.

The importance of household level amenities such as availability of latrine, drainage, access to safe drinking water and clean energy for cooking purpose is not significant mainly because of the nature and pattern of urbanisation that has been taking place in India. That towns are functionally classified into five categories – industrial towns, transport cities, commercial towns, mining towns and Garrisson Cantonment towns – and the settlements are compact, people are exposed to poor quality of outdoor air to a great extent. In addition to the patterns of settlements the rapid growth of industrial sectors that employ a large chunk of work force as informal workers also provide with poor quality of air at workplaces. This is also reflected in other findings which show that participation in sectors that are largely casual and informal in nature leads to high burden of income loss due to ailment in urban areas.

The regression results suggest that population with higher burden of income loss is also not availing the government health facility. It may indicate that either people do not access health care in general or do not access government health care when they are sick. The NSS (2014) data reveal that quality, shortage of human resources and reach are the major bottlenecks in accessing government health care services in urban areas (Table 10).

Table 10: Reason for not seeking medical advice in urban areas.

Reasons	Respondents (%)
No medical facility available in the neighbourhood	1.66
Facility of satisfactory quality not available	2.94
Quality satisfactory but facility too far	6.42
Quality satisfactory but involves long waiting	2.73
Ailment not considered serious	67.79
Other	18.44

Note: Figures are weighted according to NSS formulae.
Source: Authors' calculation based on NSS 71st (2014) unit level data.

It was found that over 50 percent of the respondents in urban areas reported the inadequacy of facilities and poor quality services to be the major reasons for not availing government health care services. Further, over 42% of the respondents said that although the quality of government health care services was satisfactory they could not avail it either because it was too far or because it involved long waiting. While distance of health care service indicates the problem of availability the long waiting for availing such services indicates mismanagement or shortage of human resources in the government hospitals in urban areas. It is known, that the health care costs where 90 per cent are private expenditures may cause economic distress leading to vulnerable situation for the poor. Hence, if population belonging to economically weaker section is not accessing government health care, it perhaps implies something more about the quality of the government health care facilities.

However, around 68 percent of the respondents didn't seek any healthcare services because they didn't perceive the ailments to be serious (Table 11).

Table 11: Reasons for not availing government treatment in urban areas.

Reasons	Respondents (%)
Required specific services not available	7.09
Available but quality not satisfactory	43.34
Quality satisfactory but facility too far	10.11
Quality satisfactory but involves long waiting	31.87
Financial constraint	0.67
Other	6.92

Note : Figures are weighted according to NSS formulae.
Source: Authors' calculation based on NSS 71st (2014) unit level data.

This indicates the lack of awareness about health and subjectivity bias as one often observes with the self-reported data on health and illness.

As it is widely discussed in the literature, one can hypothesize that urbanization characterized by industrialization and modernization in transport facilities may reduce the environmental quality in the early stages of development. India has started the process of industrialization way back during the second plan period onwards. Consecutively the industrial pollution, particularly, the contamination of water bodies due to industrial effluent discharge and the emission of pollutants to air started drawing attention during early 1990s. The situation was so grave that there were many environmentally hazardous industries that were shut down or provided with the closure notice during mid-1990s to early 2000 in industrialized States, such as Gujarat, Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh. Although there are many limitations in the way the monitoring authorities and the pollution control boards operate at central and State levels, the awareness about protecting environment seems to have improved overall (Ghatak, 2016). However, the working conditions in various industries are yet a major concern (Lalitha and Ghatak, 2015).

It is often argued that environment affects everyone irrespective of caste, class or gender. Poor quality of surface/ground water and air affect the entire community that has exposure to the polluted space. However, there are other socio-economic and demographic factors that lead to the variation in the extent of impact of environmental pollution on human health. The burden of illness due to air pollution in urban settlements draws inference of social clusters of workers in the informal or unorganised enterprises and

in accessing the government health care facilities. It is interesting to observe in the regression results (Table 9) that individuals belonging to STs and SCs are more prone to suffer from income losses due to illness caused by air pollution. Participation of STs and SCs taken together in the informal and/ casual types of work is over 52% in the urban areas (NSS, 2014). In any urban settlements in India STs and/SCs are relatively new entrants compared to other social groups. As a result, they normally reside in the clusters at the outskirts of cities and work largely in the informal sector. The settlements of STs in urban areas are in many cases outcomes of migration from the villages within a State or outside the State. For instance, in the villages in south Gujarat there was a change taking place in early 1960s in the relationship between upper caste landowners and lower caste agricultural workers. This triggered the non-agrarian employment with its growing significance over the decades (Breman, 1996). The destinations of those workers who left or pushed out of agriculture were the industries including manufacturing, mining and quarrying, and construction that operate largely as informal sector.

Although the urban areas provide the opportunity for skilled and educated people, the cities exhibit high level and pace of inequality which reflects the greater opportunity available to skilled and educated people as well as those endowed with wealth and access to social networks for employment and other income-generating opportunities since globalisation in 1990s . Such advantages are associated with the socially advantaged to a higher degree than the other social groups (Kannan,2014). Inequality in terms of mean consumption also found to be the lowest among STs/SCs with this social group experiencing a decline in the mean consumption expenditure between 2005 and 2010 (Kannan, 2014). In a scenario of high informalisation in the labourmarket,the high impact of air pollution related illness on loss of income reinforces the nexus between health and income poverty in urban areas particularly among the socially weaker sections of population.

5. Concluding remarks

The process of urbanization in India has not been structured and does not follow any uniform pattern. In recent times, increase in urbanization in peripheral areas with a transformation towards low or medium skill industrialization has been observed. Along with it there has been increased evidence of forming urban clusters in and around industrial areas drawing

marginalized migrants from rural areas. This process of urbanization and per se industrialization has an impact on the health of the local residents. This industrialization process has been informal and has lacked both technical and financial support to maintain quality in the production process resulting in higher level of pollution.

The paper investigates the burden of diseases caused by air pollution and tries to find out the relation between urbanization and air pollution in the urban areas. With the doubling of class IV cities over the last ten years and gradual shifting of industries (polluting) from the core to the periphery and increase in informal sectors the air pollutionhas also increased. Proximity of these industries to urban centres led to gradual worsening of air quality. This has been coupled with increasing marginalization of certain sections of the society due to the non-availability of health care facility in proximity and also due to poor quality of the available health facilities.

Pertinent to mention that air pollution related diseases have resulted in more income loss than any other ailments. Informalisation has made people more vulnerable in the process. These sectors provide casual employment and the entire burden of income loss for the employees has to be borne by them. The paper also highlights that the backward class is being affected much compared to other sections of the society and the situation is further aggravated due to the high level of inequality in urban centres.

Non availability of health care facilities, casualisation of labour and high informalisation in the labour market are the main reasons for the burden of income loss due to air pollution. Though the awareness about protecting environment has improved overall over the years, air pollution has been on the rise not even in urban cities but also in other urban conglomerates. With increase in economic growth, the country has improved it's per capita income but with a cost of increased morbidity which results in the burden of economic loss.

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2. **Industry, Infrastructure and Trade**
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3. **Employment, Migration and Urbanisation**
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4. **Poverty and Human Development**
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5. **Regional Development, Institutions and Governance**
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Much of the research informs national and regional policies. The Institute also undertakes collaborative research and has a network with governments, academic institutions, international organisations and NGOs. A foray into specialized training and doctoral programme has just been made.

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