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Original Article

Impact of SAFAR Air Quality Forecasting Framework and Advisory Services in Reducing the Economic Health Burden of India

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Abstract: The economic loss attributable to air pollution and associated disease burden is increasing in polluted megacities all over the globe; Indian megacities are no exception. India has launched the System of Air Quality and Weather Forecasting and Research (SAFAR) framework to provide air pollution health advisories well in advance through various outreach activities. We hereby estimate the economic benefit of SAFAR outreach attributed to prevention by intervention through an early warning based on a probabilistic scenario adopted in this work for the top two megacities of India, namely, Delhi and Pune, for the period 2011-2012 to 2019-2020 and 2014-2015 to 2019-2020 respectively. This study considers the cost-saving in pulmonary (Asthma, COPD, etc.) and other related diseases linked to air pollution. Results show that the annual average total cost of all diseases in Pune and Delhi is INR 9,480 million and INR 76,940 million respectively. We found that the total annual treatment cost of Allergic rhinitis OPD treatment cost was the highest (INR 14,490 Million) followed by asthma (INR 10,010 Million), and COPD (INR 5,140 Million) in Delhi during the year 2012. In Pune, annual treatment costs of Allergic Rhinitis, COPD and Asthma were INR 3,590, 890 and 710 Million respectively during the year 2015. SAFAR framework can make average annual savings of ≃INR 10,960 million in Delhi and ≃INR 1,000 million in Pune in the health sector, even if only 5% of the total affected sick population takes advantage of its services. Looking at the huge economic benefits, it is envisaged that the SAFAR framework model may be replicated in many more cities along with other mitigation measures rigorously.

Keywords: air quality, SAFAR, health, pulmonary diseases, economic costs, outreach activities

JEL Code: Q56, F64, Q53, Q52

1. Introduction

Research and investigation of the health burden attributed to air pollution have been dramatically increased in the last decade (Baklanov & Zhang, 2020) as it becomes a significant planetary health problem (Hadei et al., 2020). In India, many megacities feature in the world's top 10 most polluted cities (IQAir, 2020). Although exposure to air pollution and the associated disease burden is heterogeneous within the countries (Salvi et al., 2018; Dierick et al., 2020) adverse effects of air pollution on health have been increasing in India (Balakrishnan et al., 2018). Nearly 77% of the Indian

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population is exposed to $PM_{2.5}$ exceeding the annual permissible limit of 40 μg/m^3 set by National Air Quality Standards in India (WHO standard is 10 μg/m^3) (Krishna et al., 2020). The total death attributed to air pollution has been increased from 1.24 million (95% UI 1.09-1.39) in 2017 to 1.67 million (95% UI 1.42-1.92) in 2019 (Pandey et al., 2021). As per the Global Burden of Disease comparative risk assessment for 2015, air pollution exposure contributes to approximately 1.8 million premature deaths and 49 million disability-adjusted life-years (DALYs) lost attribute to air pollution (Dandona et al., 2019). Noncommunicable diseases (NCDs) have become a global public health problem (Olawuyi & Adeoye, 2018), and prevalence is rising (Kelly & Fussell, 2015; Nunes et al., 2017). Ambient air pollution is one of the drivers of the development of NCDs because it causes many NCD-related deaths (Dhimal et al., 2021). NCDs cause over 36 million annual deaths globally; 14 million are premature mortality (Subramanian et al., 2018).

Long-term exposure is associated with disease burden (Laurent et al., 2007; Pandey et al., 2021), and short-term exposure to air pollutants is closely related to Chronic Obstructive Pulmonary Disease (COPD), cough, shortness of breath, wheezing, asthma, respiratory disease, and high rates of hospitalization (a measurement of morbidity) (Manisalidis et al., 2020). Exposure to ambient $PM_{2.5}$ pollutions is associated with asthma exacerbations, cardiovascular events, and premature deaths associated with 26.2% of global disability-adjusted life years. Pulmonary diseases attributed to air pollution by $PM_{2.5}$ are associated mainly with COPDs (Burnett et al., 2014) Air pollution has various health effects even on low pollution days (Reddy et al., 2019). The worst affected megacity of the world, Delhi, is also known as the capital of Asthma (Dandona et al., 2017; Beig et al., 2021a). It had a 1.7-times higher prevalence of respiratory symptoms (Rizwan et al., 2013) as compared to rural controls ($P < 0.001$). Along with Delhi, the morbidity related to respiratory diseases is significantly increasing in Pune. Life expectancy is becoming low, and a future increase in $PM_{2.5}$ concentration may worsen the situation (Ghude et al., 2016). To protect citizens from unhealthy air, real-time air quality forecasting and assessment systems can help prevent acute episodes' health effects (Baklanov & Zhang, 2020). Exposure can be reduced by developing air quality forecasting, prediction, and advisory services (Kumar et al., 2018). In Canada, the number of asthma-related emergency department visits decreased by 25% (Chen et al., 2018) due to daily forecasts.

Ambient fine particulate matter ($PM_{2.5}$) exposure is the leading environmental risk factor globally for increasing the burden of disease (Cohen et al., 2015). Asthma burden could be avoided by reducing ambient air pollution at global level (Anenberg et al., 2018). The economic cost of estimated premature mortalities associated with $PM_{2.5}$ exposure is higher than total expenditure on health by public and private expenditure (Ghude et al., 2016). A study published by the World Bank in 2016 revealed that air pollution cost in India approximately 8% of its GDP or $560 billion in 2013 due to lost productivity due to premature mortality and morbidity (Srinivas et al., 2016; Centre for Environmental Health, 2017). The high burden of death and disease due to air pollution and its associated substantial adverse economic impact from a loss of output could impede India's aspiration to be a $5 trillion economy by 2024 (Pandey et al., 2021). Total losses from NCDs associated with air pollution in China in 2015-2030 are estimated to be $499 billion (Chen & Bloom, 2019). Annual average cost of asthma per patient INR 2,089 per year in south India which increases the economic burden to family and society (Aneeshkumar & Singh, 2018). Criteria air pollutant PM_{10} has become a serious problem because of increased disease rate and treatment cost which has resulted into the increase in hospital admission in Ahvaz mega city (Effatpanah et al., 2020).

The present work focuses on India's two major megacities as a pilot study. One is a highly polluted megacity, Delhi, and another one is a relatively cleaner city Pune, located at a moderately higher altitude to estimate the economic benefit due to advanced health advisory provided by SAFAR. The data relating to the population suffering from pulmonary diseases (Allergic Rhinitis, Asthma, and COPD) attributed mainly to deteriorated air quality along with levels of $PM_{2.5}$ are used based on the most probabilistic scenario.

2. Methodology

The study focuses on two megacities where the SAFAR (safar.tropmet.res.in) project of the Indian government has been implemented (Beig et al., 2021b; Anand et al., 2019). The SAFAR project has also been recognized as a pilot project by the World Meteorological Organization (Beig et al., 2015). It consists of a dense Air quality monitoring stations (AQMS) along with automatic weather stations (AWS) within the city limits representing different micro-environments including industrial, residential, background, urban complex, agricultural zones, as per WMO guidelines which ensure the accurate representation of city environment (Grimmond et al., 2014). Figure 1 shows the location map of AQMS within the geographical domain of the city. SAFAR network provides location-specific information on air quality of major criteria pollutants in scientific terminology in near real-time, and the forecasting model used in this work (Beig et al., 2021b; Srinivas et al., 2015) provides air pollution forecast 1-3 days in advance. The implementation of SAFAR is done with an active collaboration with local municipal.

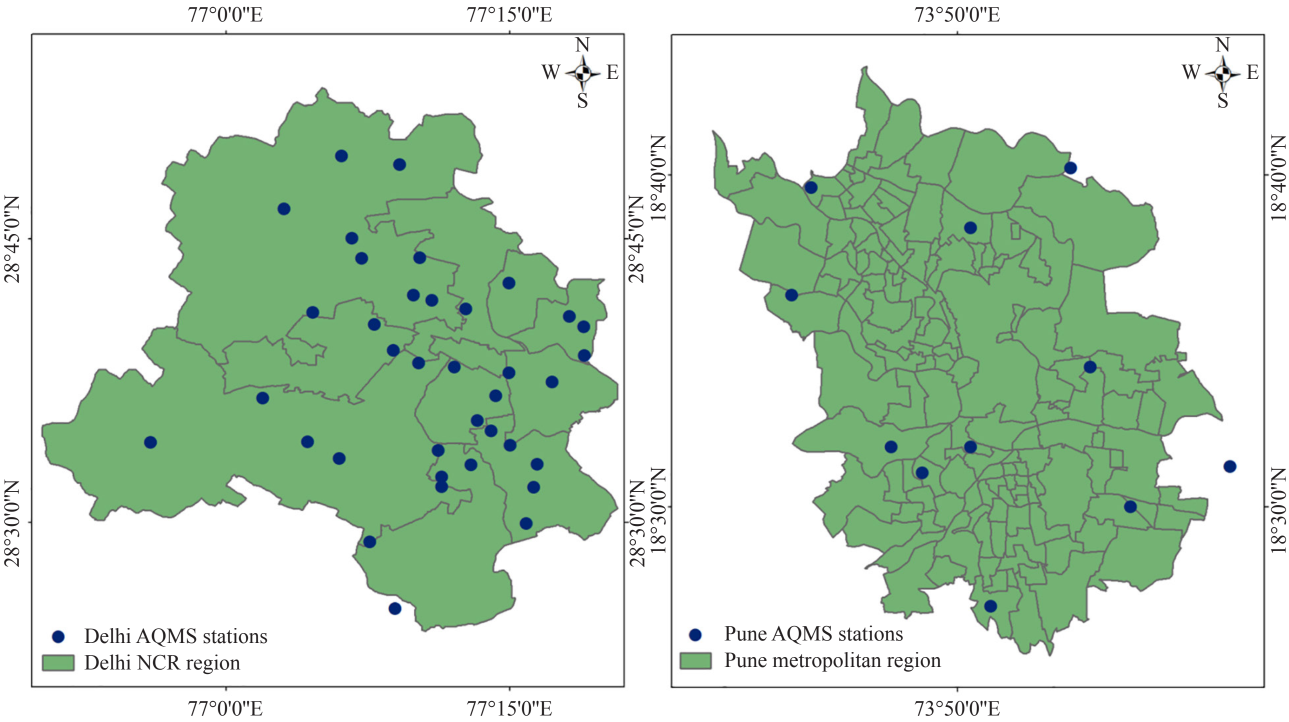

Figure 1. Observatory network information of Delhi and Pune

2.1 *Converting data to information and dissemination methodology*

The process of converting forecasted data to easy to understand information is the backbone of the SAFAR project so that preventive steps can be taken up. The path from generating scientific data and its terminology to information and decisions which can generate social and economic benefits is complex. It needs scientific understanding and its linkages with socioeconomic aspects at each step. Hence, an essential part of any alert system like SAFAR is to design a user-friendly system product and information dissemination tools so that the information products generated through the system can be utilized by various stakeholders. The Air Quality Index (AQI) concept is adapted by many developing countries (USEPA, 2005) to communicate pollution levels to the common public in an easy to understand format. AQI is a rating scale used for reporting the quality of the air we breathe in and the associated health effects. It provides information in terms of color and simple numbers without any units which can be easily comprehended by the common public. There are six AQI categories, namely Good, Satisfactory, Moderate, Poor, Very Poor, and Severe, as per official Indian government guidelines (MoEFCC, 2015). The breakpoint for the concentration for two major pollutants PM_{10} and $PM_{2.5}$, which determine the AQI in the Indian metro, is given in Table 1.

SAFAR generates the following products for awareness generation leading to economic benefit through intervention:

1. Air quality: AQI based location-specific current and three days advance air quality forecast.
2. Extreme events: Alert for severe pollution and weather events.
3. Advisories: Information about impact on human health and advisory on precautionary steps to be taken by

various age groups and health conditions.

4. Emission scenario: To generate pollutant emission hot spots map at the city level to identify avoidable areas.

To disseminate the information related to SAFAR products, the following tools are designed:

1. SAFAR-AIR-Mobile App: Available at google store and app stores.
2. SAFAR-INDIA: Dynamic web portal: Available at: http://safar.tropmet.res.in/.
3. LED-Digital display boards installed at various locations in the city for data screening.
4. SAFAR-IVRS (Integrated Voice Response Service) with a toll-free number.
5. Registration, advice on alert Services through online and e-mail-*safar@tropmet.res.in.*

Table 1. The concept of Air Quality Index (AQI) for India and breakpoints of PM_{10} and $PM_{2.5}$ for different categories with color coding

Description and Colour Coding	Air Quality Index (AQI) Range	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)
		24 hr avg	24 hr avg
Good	0-50	0-50	0-30
Satisfactory	51-100	51-100	31-60
Moderate	101-200	101-250	61-90
Poor	201-300	251-350	91-120
Very Poor	301-400	351-430	121-250
Severe	401+	431+	251+

All the activities of SAFAR, from receiving data to dissemination, are controlled by the SAFAR-Master control center (SMCC) located in Indian Institute of Tropical Meteorology (IITM), Pune. It houses all important servers and prototypes of customized control software. The data and products generated are used for scientific research and development purposes and services to society. For further detail, the reader is referred to visit the SAFAR website (http://safar.tropmet.res.in). The registration, mobile app downloads, and website visits daily provided us a rough estimate on the usage of this SAFAR application which led us to make assumptions on the percentage number of affected people taking advantage of our advisory. In addition, print and television media covers SAFAR information routinely in some or other form whose coverage increases during peak pollution time like winter season. The estimation of people takes advantage of SAFAR information in print and visual media (television, display boards, IVRS-services) is highly effective but hard to estimate the number as newspapers are read by several millions of people all over the country and display boards are seen by many people in the streets where they are erected. However, an estimated number of more than a million people downloaded the different versions of SAFAR-Air mobile app in the different platforms since its inception. An equal number of hits per year are noticed for SAFAR website and daily visits during extreme pollution period increase many folds I so much so that website slows down. We are also receiving the queries and mail for detailed information on air quality status from many people who visited the website, using our app and after observing values of AQI on LED displays installed at various prime locations of cities. All the queries are being answered by our technical team and experts of the air pollution and monitoring division regularly.

A systematic review was conducted to identify all published studies on major respiratory Noncommunicable Diseases (NCDs) (Nethan et al., 2017; Nunes et al., 2017; Rehr et al., 2018; Salvi et al., 2018; Akkawi et al., 2020; Hadei et al., 2020; Pandey et al., 2021; Rehman et al., 2021) to understand the cost implications. Overview of the cost reported in studies by different researchers has been depicted in Table 2. In the present study, the population suffering from respiratory NCDs, namely Allergic Rhinitis, Asthma and COPD are only considered for cost estimation.

Information related to OPD, IPD, and ICU patients' costs against these diseases were collected based on government and medical facility providers to adopt the broad societal perspective. To aware the general people about the health impact SAFAR disseminating location-specific health advisory information (Table 3) depending on AQI of the day, using the above-mentioned products in four megacities. To spread the awareness in the young generation specifically in student SAFAR also launched comprehensive school flagship program in two cities of India, Ahmadabad, and Pune. This will help to educate and protect the students from the adverse health impacts of air pollution.

Table 2. Results indicating cost associated with NCDs

Source	Place	Diseases	Costing perspective Government/Social/ Patient/Reports	Annual cost
(Wu et al., 2020)	India	NCDs	Combine	U$ 8.7
(Barik & Arokiasamy, 2016)	India	NCDs	Direct (Govt.)	84240 Million
(Barik & Arokiasamy, 2016)	India	NCDs	Direct (Private)	457340 Million
(Brandt et al., 2012)	California	Asthma	Combine	~US$3,800-4,000
(Krishna et al., 2020a)	India	Asthma	-	INR 71 billon (~USD 7 billion)
(Kulthanan et al., 2018)	Asian countries	Allergic rhintis	Government	USD 34.
(Joshi et al., 2020)	India	Severe Asthama	Interviewed of selected physician and patients	INR 1,18,303
(Rehman et al., 2021)	Malaysia	COPD	Direct cost Interviewed of patients	US$506.92
(Zafari et al., 2021)	United States	COPD	Model with publically available data set	$800.90 billion (for 20 years)
(Sean et al., 2000)	United States	COPD	Direct	$14.7 billion

Table 3. AQI colour signal system for SAFAR-India health alert

Air Quality Index (AQI)	PM 2.5 Health Advisory	PM 2.5 Health Effect Statement
Good (0-50)	No cautionary action required	Air pollution poses no risk
Satisfactory (51-100)	No cautionary action required	Air pollution poses little or no risk
Moderate (101-200)	Unusually sensitive people should consider reducing prolonged or heavy exertion and heavy outdoor work	Air quality acceptable for public but moderate health concern for sensitive people
Poor (201-300)	Children and adult with heart or lung disease, should reduce prolonged or heavy exertion and limit outdoor activity	Children and adult people at risk. More chances of precipitating respiratory symptoms in sensitive individuals.
Very Poor (301-400)	Everyone should reduce prolonged or heavy exertion. More caution for children or adult with heart or lung disease.	Trigger health alert. Everyone may experience more health effects. Significant increase in respiratory effects in general population
Severe (401-500)	Everyone should avoid all outdoor physical activity. Sensitive individual should remain indoor with minimal activity.	Should be declared as emergency condition. Serious risk of respiratory effect in general population as high risk.

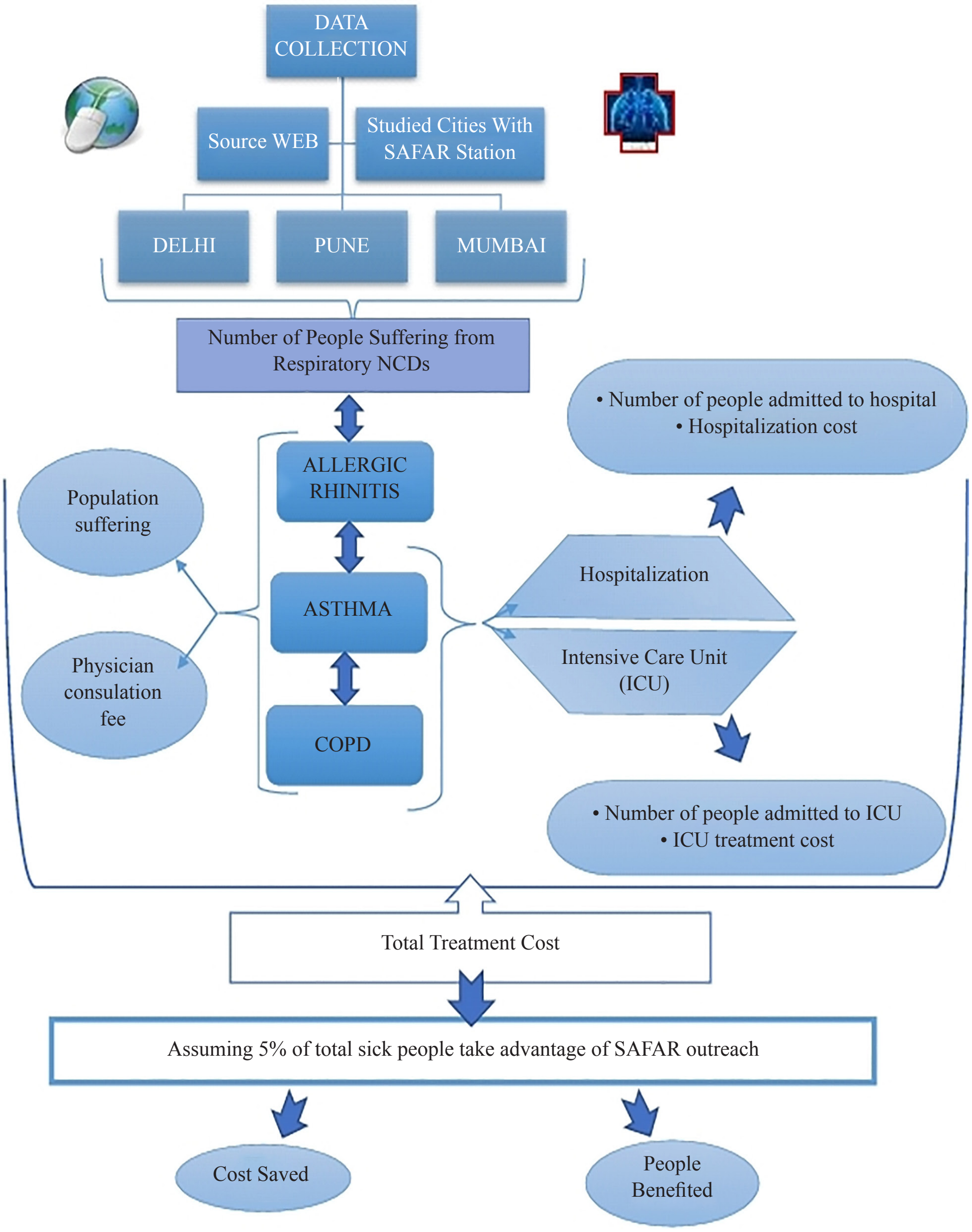

Figure 2. Detailed methodology used for the present study

For the estimation of total cost spent by affected people, the cost of government and private hospitals are considered as per the ratio of Above Poverty Line (APL) and Below Poverty Line (BPL) population (Table 4). Total treatment cost from the base year 2011-2012 for Delhi and 2014-2015 for Pune after the installation of SAFAR air quality network to 2019-2020 has been estimated. The total annual direct cost of the patients is the multiplication of 12 months by per-patient cost. The total average per patient cost has been a sum of the entire medical cost per affected capita in government hospitals and private hospitals. Unit treatment cost estimates were based on a review of older published studies and different authentic sources, and incremental cost estimates were applied depending on projected inflation rates. Figure 2 describes the methodology of the present study in brief. Statistical analysis is used to assess the impact of SAFAR outreach based on the following assumptions, which we consider as limitations of our work and maybe a cause of uncertainty.

Table 4. Above Poverty Line (APL) and Below Poverty Line (BPL) Ratio

CITY	APL (%) (prefers treatment in a private hospital)	BPL (%) (prefers treatment in government hospital)
DELHI	90.16	9.84
PUNE	90.88	9.12

- 5% of total sick people take advantage of SAFAR outreach
- Outreach increase of SAFAR by 2% each year
- Per year increase in population is 1%
- Treatment cost rise due to inflation is 10% each year

The average cost is considered from different sources (https://www.cghs.nic.in, https://cghs.gov.in/, https://www.cghspune.gov.in, https://www.medifee.com, and https://phfi.org). Details of treatment cost for Pune and Delhi is depicted in Table 5 and Table 6 respectively.

Table 5. Economic Assessment of "SAFAR" in PUNE (2015)

Population of PUNE in 2015: 0.57 Crore (CR)	5,745,577		Mean Cost of the Total Population Suffering							Cost (Million)
			People affected	People affected	Cost (Rs)	A	People affected	Cost (Rs)	B	
Prevalence of illness	Range (%)	Number of people suffering (%)	(IN NUMBER)	9.12% Prefer Government Hospital	Per Patient	Total Cost (INR)	90.88% Prefer Private Hospital	Per Patient	Total Cost (INR)	Total Treatment Cost
Allergic Rhinitis	10-30	20.00	1,149,115	104,799	1,620	169,774,906	1,044,316	4,620	4,824,740,269	4,990
Asthma	3.0-4.9	3.98	228,387	20,829	1,620	33,742,762	207,558	4,620	958,917,128	990
COPD	4.9-5.02	4.96	284,981	25,990	1,620	42,104,177	258,990	4,620	1,196,535,587	1,240
Hospitalization for COPD	0.18-0.12	0.191	10,984	1,002	810	811,434	9,983	7,908	78,942,038	80
ICU Management severe COPD	0.11-0.13	0.121	6,971	636	531	337,577	6,335	4,136	26,201,901	30
Hospitalization for Asthma	0.05-0.1	0.097	5,550	506	810	410,006	5,044	6,363	32,095,269	30
ICU management for Asthma	0.01-0.05	0.035	1,982	181	531	95,994	1,801	4,136	7,450,777	10
TOTAL COST (Rs.) for all ailing people-2015			1,687,970		7,542	247,276,856		36,403	7,124,882,969	7,370

Table 6. Economic Assessment of "SAFAR" in DELHI (2012)

Population of DELHI in 2012: 2.2 Crore (CR)	22,000,000		Mean Cost of the Total Population Suffering							Cost (Million)
			People affected	People affected	Cost (Rs)	A	People affected	Cost (Rs)	B	
Prevalence of illness	Range (%)	Number of people suffering (%)	(In Number)	9.84% Prefer Government Hospital	Per Patient	Total Cost (INR)	90.16% Population Prefer Private Hospital	Per Patient	Total Cost (INR)	A + B
Allergic Rhinitis	10-12	11	2,420,000	238,128	2,880	685,808,640	2,181,872	9,096	19,846,307,712	20,530
Asthma	7.4-7.8	7.6	1,672,000	164,525	2,880	473,831,424	1,507,475	9,096	13,711,994,419	14,190
COPD	3.5-4.3	3.9	858,000	84,427	2,880	243,150,336	773,573	9,096	7,036,418,189	7,280
Hospitalization for COPD	0.080-0.100	0.089	19,472	1,916	1,680	3,219,016	17,556	123,921	2,175,586,461	2,180
ICU Management severe COPD	0.001-0.030	0.015	3,296	324	2,090	677,790	2,971	8,884	26,398,318	30
Hospitalization for Asthma	0.400-0.500	0.427	190	9,243	1,680	15,527,554	84,686	78,261	6,627,625,550	6,640
ICU management for Asthma	0.080-0.089	0.081	17,852	1,757	2,090	3,671,363	16,095	8,884	142,990,891	150
TOTAL COST (INR) for all ailing people-2012			4,990,810		16,180	1,425,886,123		247,238	49,567,321,540	50,990

• In this study, we considered only those diseases which have proven evidence to be caused by air pollution (NCDs) and may impact the total infected population and increase India's economic burden.

• However, a considerable difference exists in the cost of treatment in public and private sectors, and the estimate may be higher than the average actual costs estimated.

3. Result and discussion

Figure 3 shows the percentage of the affected population attributed to air pollution-related illness. The prevalence of allergic rhinitis is highest among people (Figure 3a). An almost double proportion of the affected population (20%) was observed in Pune city compared to Delhi (11%), whereas the opposite prevalence of asthma was observed at 4% in Pune and 8% in Delhi. But the asthma burden assessment is a challenge due to huge variation in symptoms (Nunes et al., 2017) in India. It exceeds the number of people with HIV infection or tuberculosis (Krishna et al, 2020). Delhi and Pune reported an overall low prevalence of COPD estimate at 4% and 5%, respectively. A similar finding for Pune was also reported by (Rajkumar et al., 2017). The difference was particularly evident in people's hospitalization due to asthma's highest in Delhi (0.45%) and comparatively low in Pune (0.10%). A similar trend in ICU management of asthma was also observed at 0.03% in Pune and 0.08% in Delhi (Figure 3b). The rate of hospital admissions for asthma and COPD has increased in recent years (Salvi et al., 2018). People hospitalized due to COPD is found 0.19% and 0.09% in Pune and Delhi respectively. People admitted with COPD in ICU represented 0.12% in Pune, and relatively low 0.01% people in Delhi represented people in ICU with COPD. Though the study adopted standardized procedures, it did not have adequate power to generate dependable prevalence estimates. The mortality risk of COPD in the elderly men is associated with extreme low temperatures (Zafirah et al., 2021).

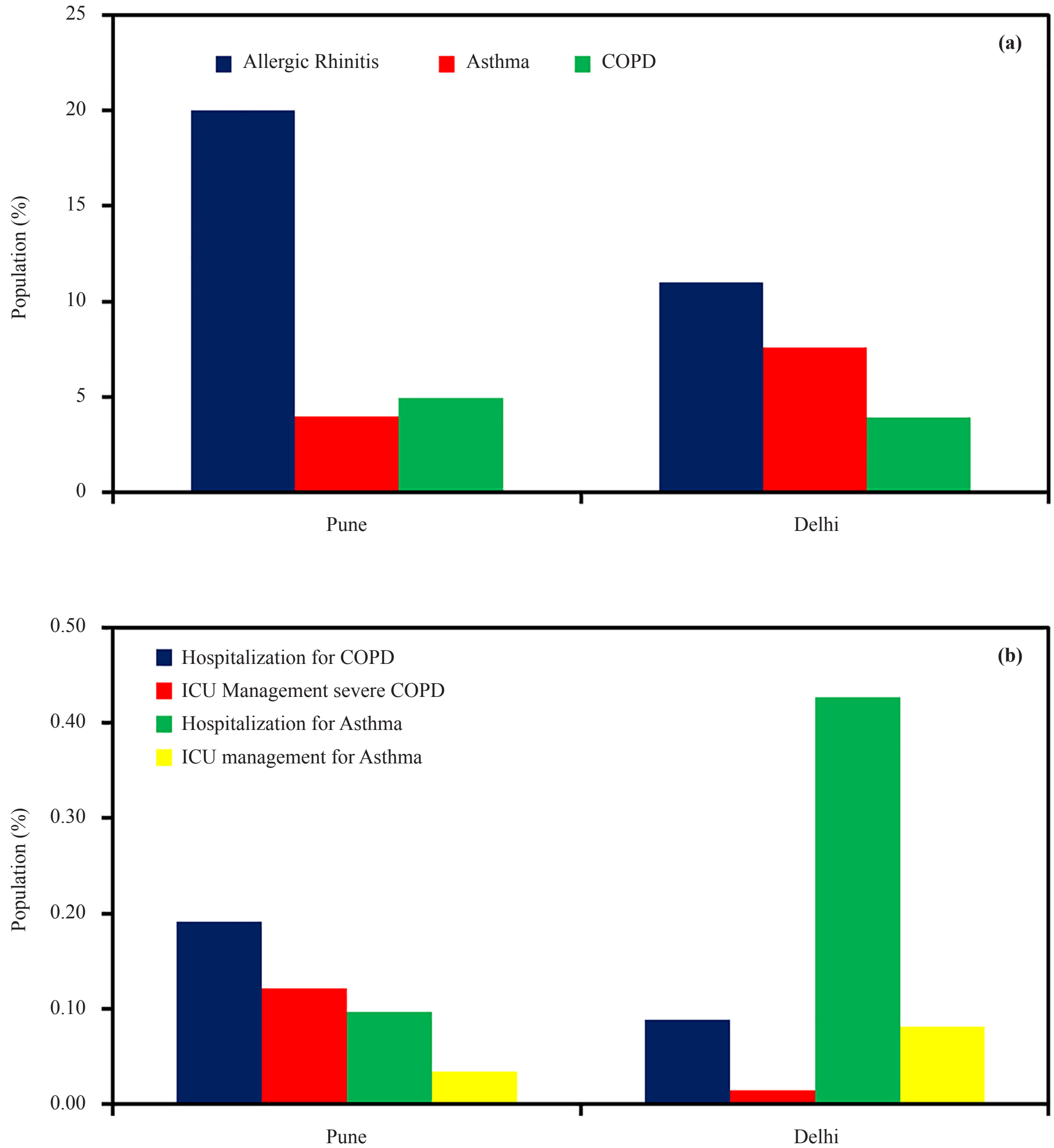

Figure 3. Affected population due to Allergic Rhinitis, Asthma, COPD (a) percentage of population hospitalized or admitted ICU (b)

The direct healthcare costs consist of formal healthcare goods and services (hospital, physician, nursing, home care, drugs (Dierick et al., 2020). In the present study, we focus on the physician, considering OPD treatment cost, hospitalization, and ICU management cost. The average treatment cost of an affected population due to allergic rhinitis, asthma, COPD, and cost due to hospitalization and ICU management cost for COPD and asthma has been summarized in Figure 4. Annual average treatment costs attributable to Allergic Rhinitis, asthma, and COPD are higher in Delhi than in Pune city (Figure 4a). The biggest contributor to medical cost in Delhi was the OPD treatment cost of people with Allergic Rhinitis (INR 14,490 Million), asthma (INR 10,010 Million), and COPD (INR 5,130 Million), whereas in Pune Allergic Rhinitis treatment cost was highest (INR 3,580 Million), followed by COPD (INR 890 Million) and Asthama (INR 710 Million). The main driver of direct non-medication costs was hospitalizations for COPD patients being the highest cost component INR 1,222.8 Million in Delhi (Figure 4b), whereas in Pune, it was INR 47 Million. However, the average cost estimated for Asthma is INR 1.90 Million in Pune and INR 7.5 Million in Delhi. Asthma ICU management cost is dominant in Delhi (INR 97 Million) compared to Pune (INR 4 Million). Raising awareness of COPD at national and local levels should eventually reduce COPD's global burden (Zielinski et al., 2006). The total estimated economic burden of these diseases, including Hospitalization and ICU management, is INR 10,550 Million in Pune in 2015 and INR 61,970 Million in Delhi in 2012. The lost output from premature deaths and morbidity attributable to air pollution accounted for economic losses of US$28.8 billion (21.4-37.4) and $8.0 billion (5.9-10.3), respectively, in India in 2019 (Pandey et al., 2021).

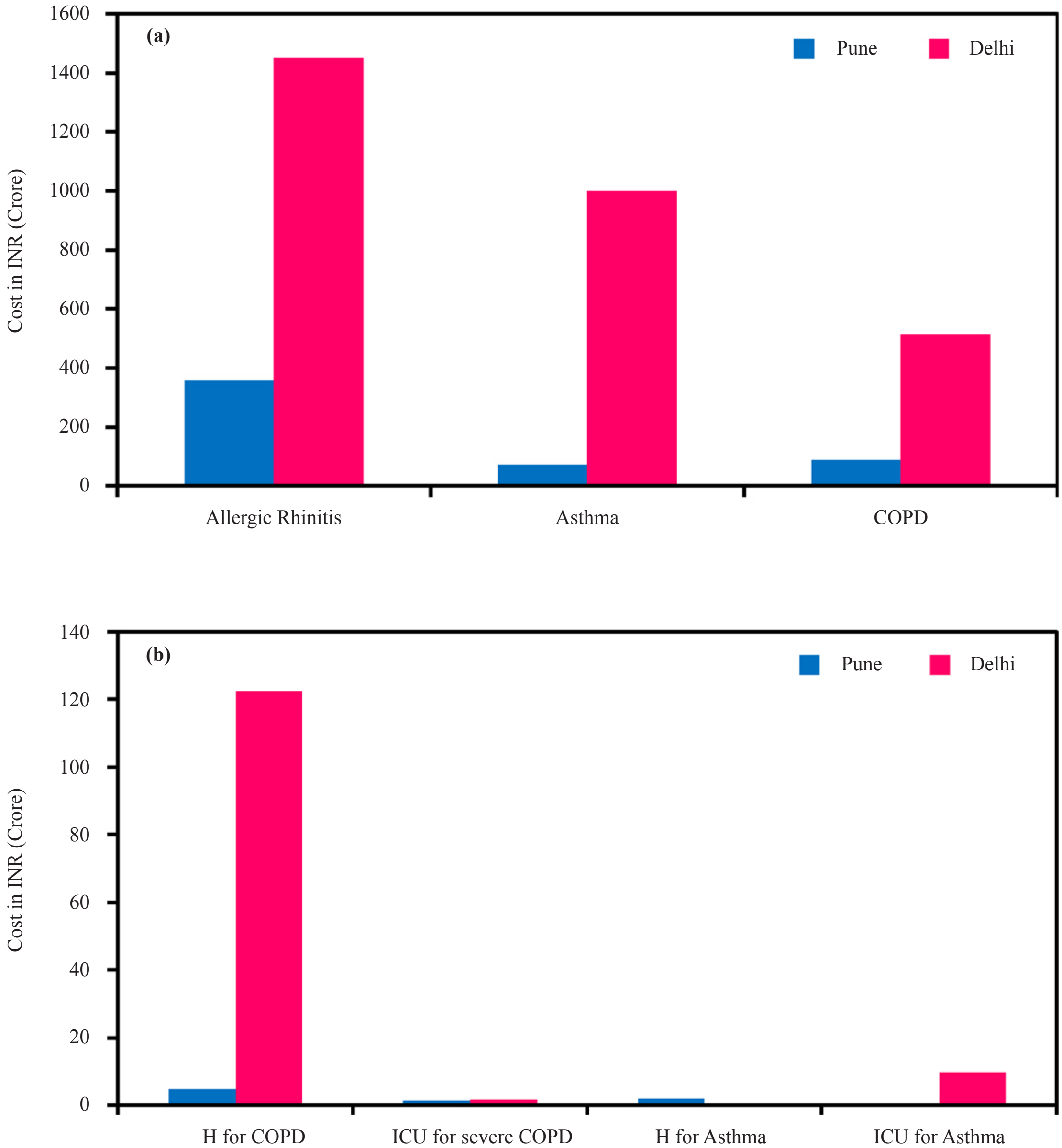

Figure 4. Average OPD treatment cost of the affected population in Pune and Delhi due to (a) Allergic Rhini Asthma, and COPD; (b) treatment cost for H (hospitalized) and ICU (Intensive Care Unit) for COPD and Asthma

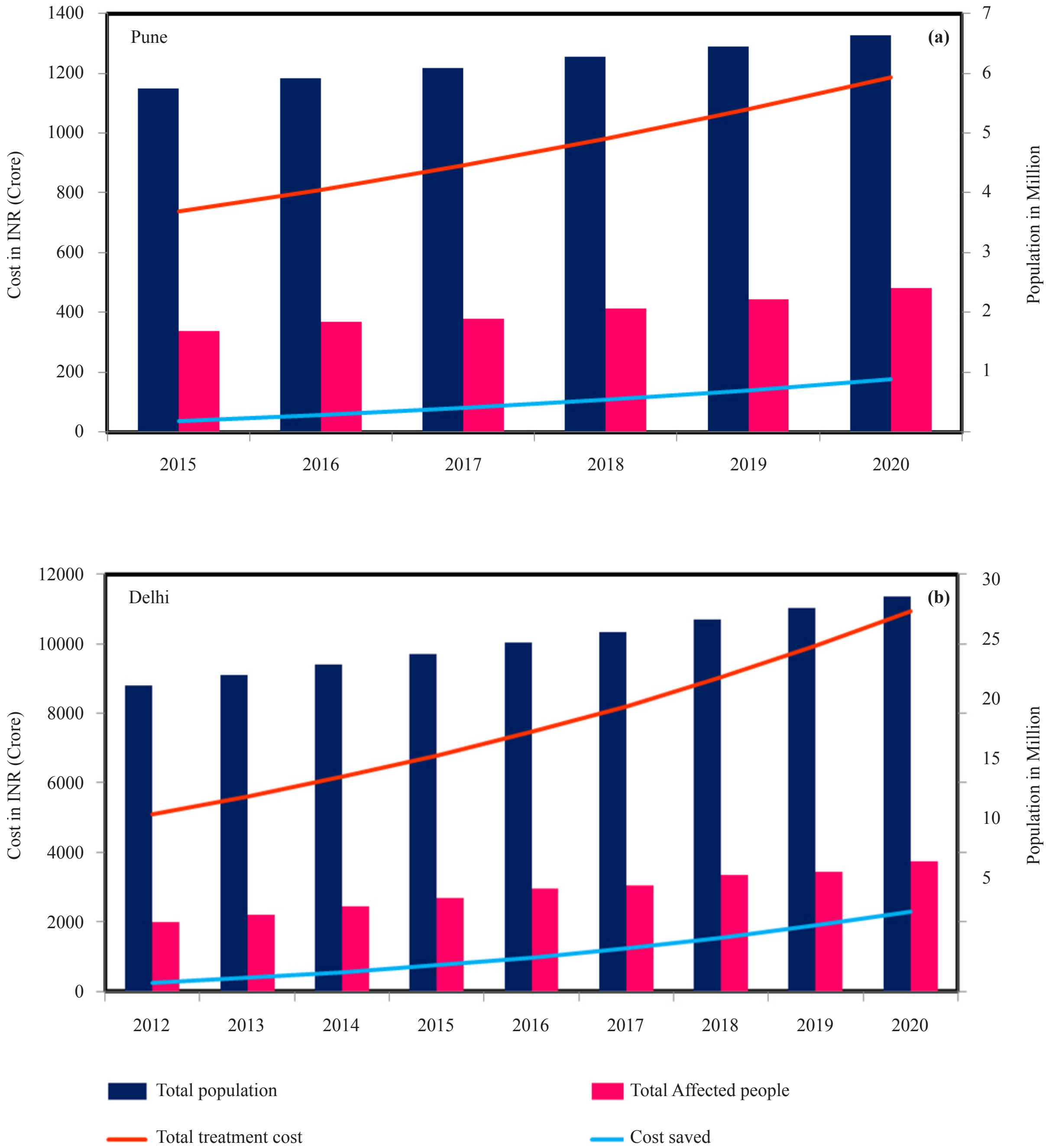

Figure 5. Predicted saved cost in INR (crore) due to SAFAR outreach in Pune (a), and Delhi (b)

The cost saved on treating respiratory NCDs because of SAFAR outreach, as shown in Figure 5 estimated as per the methodology's assumption. The total economic cost burden in Delhi city from 2012 to 2020 is much higher than the increased cost in Pune city in the last five years. By considering an average increase in SAFAR outreach per year, in 2020, the economic cost burden can be reduced by 22,950 Million and 1,780 Million in Delhi and Pune. This will help reduce the economic burden of our country as India has 18% of the global population and an increasing burden of chronic respiratory diseases. The contribution of chronic respiratory diseases to the total DALYs in India increased from 4.5% (95% UI 4.0-4.9) in 1990 to 6.4% (5.8-7.0) in 2016 (Balakrishnan et al., 2018). Although the economic cost of NCD per case may not be staggering at present, future technology would be expensive. 'The share of non-communicable disease in total disease burden has increased from 31% in 1990 to 45% in 2010 in India (Barik & Arokiasamy, 2016). In 2018 (Chen & Bloom, 2019) studied the macroeconomic burden on non-communicable diseases associated with air pollution in China and showed that it imposed a large economic burden on China. Given the finite resources, the management of NCD at the macro level will pose a tougher challenge. Drivers and sources of air pollution need to be controlled immediately otherwise it is likely to result in more air pollution-related deaths (Dhimal et al., 2021). The gross picture of the trend in the affected population is also shown in Figure 5. If we increase the outreach activities like SAFAR, we can handle the problem up to some extent in an emergency. There is an acute need to increase the monitoring programs across all cities and publicly disseminate the information. While the monitoring stations can be established, legislations amended, and standards improved, these efforts will be wasted if the regular dissemination of the information is not practiced to raise awareness for pollution control (Guttikunda et al., 2014). Governments should spread sufficient information, educate people, and involve professionals in these issues to successfully control the problem's emergence (Manisalidis et al., 2020). It is also a multidimensional notion that no single socioeconomic variable (education, occupation, assets, income), considered alone, can capture (Laurent et al., 2007), which can be achieved by launching an awareness program. Two challenges that have emerged for better air quality in Indian cities are the need to secure greater public awareness of the problems and commitment to action at civic, commercial, and political levels and to ensure that action to tackle air pollution is seen in the context of wider social and economic development policies (Guttikunda et al., 2014). In another study (Wu et al., 2020) reported that health care investment could help the countries for sustainable development in Bangladesh and India.

We have provided economic burden and benefit due to SAFAR outreach based on assumptions and data limitations. We anticipate that future study will be advanced specifically with respect to affected population details an actual treatment cost of each disease at a particular hospital and actual awareness of the air pollution status. Further study can be more specific by addressing uncertainties of estimation of economic burden (Anenberg et al., 2018). For the accurate estimation of economic burden is a healthy registry (Effatpanah et al., 2020) record and the inadequate health system as the obstacle to tackle the challenge of non-communicable diseases in South Asia (Barik & Arokiasamy, 2016). Policy-maker should design a global prevention policy to combat anthropogenic air pollution and a powerful tool of environmental health protection to spread sufficient information to people and professional (Manisalidis et al., 2020). The lack of efficacy tools amid confusing information, resulting in perceptions of insufficient information and confusion, may exacerbate health disparities (Ramirez & Carmona, 2018). Accurate, timely information can be an influential tool to mitigate air pollution-associated disease and impact of communication of air quality status reduces health risks (Ramírez et al., 2019). It is increasingly important for worst polluted cities like Delhi in India and global priority, for a critical environmental health awareness perspective.

4. Conclusion

Present work systematically estimated the most conservative estimate of the economic benefit of SAFAR-an air quality early warning framework in the health sector of two of the megacities of India having diverse environment. Major conclusions of the studies are-(1) The outreach and awareness model of SAFAR framework resulted in an annual average benefit of ~INR 10,960 million in Delhi and ~INR 1,000 million in Pune; (2) The study gains importance as economic implications are crucial for the societal acceptance of mitigation action and designing and enforcing abatement policy measures; (3) Results also strengthen the assertion that awareness and early precautionary warning remain an integral component of health and economic progress; (4) As air pollution also affects many other sectors like agriculture, aviation, infrastructure, tourism, etc, there is a need to understand the benefits associated with these sectors in the future.

However, it is stressed that the present study is a pilot to understand firsthand information and not free from some uncertainties. It is constrained by the limited availability of health data and assumptions. We have assumed that the death of specific diseases is largely due to air pollution but there are some confounding factors which may have introduced some amount of uncertainty. However, future work should be extended to field surveys on the actual number of percentages of population suffering from NCD's and associated with cost burden.

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Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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