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Original Research Paper

Effectivity of Vehicular Banning and its Reflection in Disease Incidence in Kolkata

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ABSTRACT

Kolkata is one of the most polluted cities of the world. The city has been plagued by one of the most prominent pollution problems of the of the world, the air pollution. The time period of 2000-2008 saw a huge number of vehicles hitting Kolkata's streets, which has lead to a significant increase in air pollution. Realising this, the Supreme Court has decided to impose a ban on the vehicles, which are more than 15-year old. The ban was imposed finally on 1st August, 2009. It was thought that this ban would result in substantial reduction of pollution, but the reduction in SPM, RPM, SO_x and NO_x could not be achieved to the desired level. A statistical analysis through bar diagrams, box-plots and ANOVA was performed to compare the different type of pollutants to determine whether the ban on the old vehicles was effective or not. The winter season of the year 2010 saw the values of SPM (383.1 μg/m^3) and RPM (184.4 μg/m^3) returning almost to the same level as before the ban. In fact, the values went higher than the levels of 2008 (SPM - 302.4 μg/m^3, RPM - 145.3μg/m^3) and 2009 (SPM - 334.3 μg/m^3, RPM - 171.7 μg/m^3). The values of SOx and NOx also increased indicating that the ban has not been able to handle the air pollution level of Kolkata. The air pollution has been a very potent disease causing agent. The main diseases caused by air pollution are generally respiratory diseases like asthma, restrictive lung disorder, COPD (chronic obstructive pulmonary disorder), cardiovascular disease, and lung cancer. The survey of the three major hospitals in Kolkata shows that there is a huge number of patients being suffered by respiratory disorders during winter months, and the number seems to have increased after the ban has been imposed. The winter of 2010 saw 117 patients suffering from respiratory disorders as compared to the 114 in 2009 and 108 in 2008. The other diseases like cardiovascular diseases and lung cancer also had a higher number of patients in the winter of 2010 as compared to 2008 and 2009. Thus, it should be noted that the pollution has not been reduced at all by the ban. This may have occurred because the government or the officials were not able to impose the ban effectively.

INTRODUCTION

The surge of urbanization has engulfed Kolkata to the fullest. Wherever we put our eyes, we find new high rise buildings being built, more and more vehicles hitting the streets, and more and more industries being set up. There are both advantages and disadvantages of the increased urbanization. While the benefits are manifold, there is one disadvantage in the form of increasing air pollution. Even if we do not consider other kinds of pollution, the effect of air pollution in itself is the maximum, both in intensity and in destruction. Air pollution is generally measured by the parameters, suspended particulate matter (SPM), respirable particulate matter (RPM), oxides of sulphur (SOx) and oxides of nitrogen (NOx).

SPM plays a key role in determination of the amount of air pollution in metropolitan cities. The standards have been established by the CPCB (Central Pollution Control Board). But in Kolkata and other metropolitan cities, these standards are often violated, hence, the government runs scans of the concentration of SPM regularly to keep its increasing values in check. CPCB has set up standards of 120 μg/m^3 and 60 μg/m^3 for RPM in the industrial and residential areas respectively. The government also tries to undertake various methods in order to keep these standards in check.

The Kolkata has a large number of vehicles. As the old vehicles are not well maintained, they cause high pollution as compared to the newer vehicles. This invoked the government to impose a ban on such vehicles, which are more than 15 years old. This ban came into effect on August 1, 2009, and 22000 trucks, 6000 taxis, 32000 auto rickshaws, 500 mini buses and 2500 private buses were banned from the streets of Kolkata. After the ban was imposed, the air improved from the earlier pollution levels. So, we undertook an attempt to prove whether the ban was really a success or not and whether it had any relation to the diseases

Table 1: Year-wise comparison of various air pollutants (μg/m^3) for the years 2008, 2009 and 2010.

	Winter(January-February)			Summer(April-May)			Monsoon(June-July)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
RPM	145.3	171.1	184.4	51	47	43.7	34	34.9	33.5
SPM	302.4	334.3	383.1	132.3	116.3	114.4	96.8	93	92
NOx	84.9	85.5	104.1	57.6	45.3	48	44.3	43.9	42
SOx	7.8	10.1	12.2	5.2	5.5	7.4	4.9	5.2	5.1

Table 2: Patients affected due to air pollutionas as per data collected from the three hospitals.

Year	Seasons	number of patients	Sample size of each year
2008	Winter	142	366
	Summer	126	
	Monsoon	98	
2009	Winter	153	365
	Summer	117	
	Monsoon	95	
2010	Winter	157	377
	Summer	119	
	Monsoon	101	
	Total Sample Size		1108

caused by air pollution. A survey was performed in various renowned hospitals of Kolkata. We have collected data in three different seasons, summer (April-may), monsoon (June-July) and winter (January-February) in the years 2008, 2009 and 2010. *t*-test, ANOVA and box plots tests were performed to determine correlation between the diseases and the ban, and to find out whether the ban on old vehicles has been a success or failure.

MATERIALS AND METHODS

Air analysis: Air samplers having glass impingers containing specific solvents for measuring the levels of NOx and SO_2 in ambient air were used. In order to capture the particulate matter present in the ambient air, a filter paper was placed in front of the absorbing jet.

Sulphur dioxide was determined by modified West and Geake method. Nitrogen oxides were determined by absorbing them in sodium hydroxide-sodium arsenite solution and later analysing by colourimetric method. SPM and RPM (particles lesser than 10 μm) were determined by filter paper difference method using specific filter papers after passing known volume of air through them.

Statistical tests: The tests like *t*-test , ANOVA and box plates were carried out for correlating the disease incidence with levels of pollutants by standard statistical methods. The differences in the level of the air pollutants during the three seasons were also tested by ANOVA to check whether they are significant or not.

Data collection for disease incidence during pre-banning, banning and post-banning time periods: All the data were collected following the interview method in which data were collected from 3 hospitals across the city of Kolkata by direct interviews with the hospital authorities. From this we came to know about the patients suffering from diseases due to air pollution. The doctors distinguished between the various kinds of diseases by Pulmonary Function Test (PFT). Firstly, data related to patients were obtained for their name, age, gender, height, weight and smoking history. With the help of spirometry (Hancox & Whyte 2005), the following parameters were obtained: FVC (Forced Vital Capacity), FEV_1 (Forced Expiratory Volume on 1st sec) and FEV_1/FVC. Considering these values, finally diagnosis was made as the normal, the obstructive airways or the restrictive lung disorder. The differentiation of COPD from asthma was done by considering the Reversibility Criteria as mentioned by the American Thoracic Society.

RESULTS AND DISCUSSION

Year-wise comparison of RPM, SPM, NOx, SOx: Year-wise comparison of the four parameters was performed in winter, summer and monsoon seasons. The maximum value of all the parameters was found in the months of January-February of 2010, and the minimum values in June-July of the same year (Table 1).

Season-wise comparison of RPM, SPM, NOx, SOx: Season-wise comparison of the four parameters was performed for the three years separately. This showed that the winter season has the maximum values for all the three years, with 2010 showing the highest values, and monsoon season the minimum values for all the three years with 2010 showing the least concentrations (Figs. 1, 2, 3).

Patients affected by air pollution as per data collected from the three hospitals: The analysis of the three hospitals showed that the highest number of patients affected by air pollution were in the winter seasons of all the three years with maximum in 2010. The sample size year-wise was 366 for 2008, 365 for 2009 and 377 for 2010, hence the total sample size was 1108 for the three hospitals (Table 2, Figs. 4, 5).

Table 3: Patients suffering from respiratory disease, lung cancer and cardiac disease in the three seasons of 2008, 2009 and 2010.

	Winter			Summer			Monsoon		
Diseases	2008	2009	2010	2008	2009	2010	2008	2009	2010
Respiratory Disease	108	114	117	95	88	86	71	68	71
Lung Cancer	9	10	9	9	10	8	8	9	8
Cardiac Disease	25	29	31	22	19	25	19	18	22

Table 4: Patients suffering from asthma, restrictive lung disorder and COPD in the three seasons of 2008, 2009 and 2010.

Seasons	Winter			Summer			Monsoon		
YearsDiseases	2008	2009	2010	2008	2009	2010	2008	2009	2010
Asthma	38	41	42	34	30	29	27	26	28
Restrictive Lung Disorder	37	38	39	31	29	27	24	23	21
COPD	33	35	36	30	29	30	20	19	22

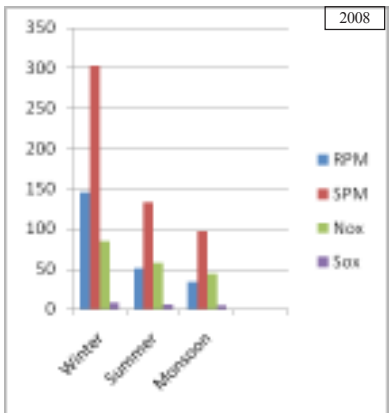

Fig. 1: Season-wise comparison of RPM, SPM, NOx and SOx in 2008.

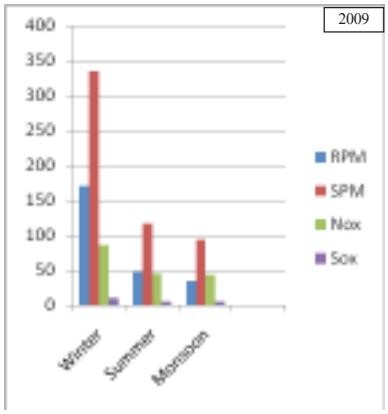

Fig. 2: Season-wise comparison of RPM, SPM, NOx and SOx in 2009.

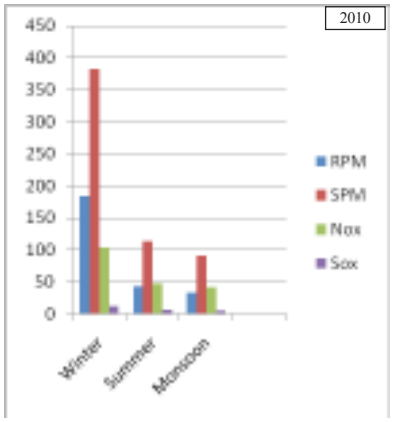

Fig. 3: Season-wise comparison of RPM, SPM, NOx and SOx in 2010.

Fig. 4: Sample size of patients during the years 2008, 2009 and 2010.

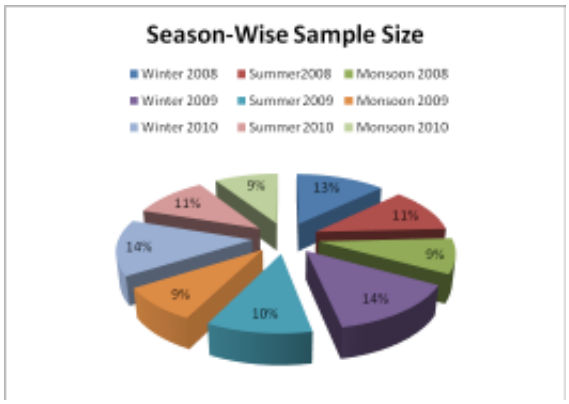

Fig. 5: Season-wise sample size of patients.

Patients suffering from respiratory diseases in the three seasons: There are three diseases selected for analysis of the effect of air pollution on health of the citizens of Kolkata. The analysis shows that the patients suffering from respiratory disease are highest. The number of cardiovascular disease patients is the second highest and the number of lung cancer patients is the least. The maximum number of patients was found in the year 2010 which is after the ban of old vehicles (Table 3).

Patients suffering from respiratory disorders in the three seasons: The three main respiratory disorders are asthma, restrictive lung disorder and chronic obstructive pulmonary

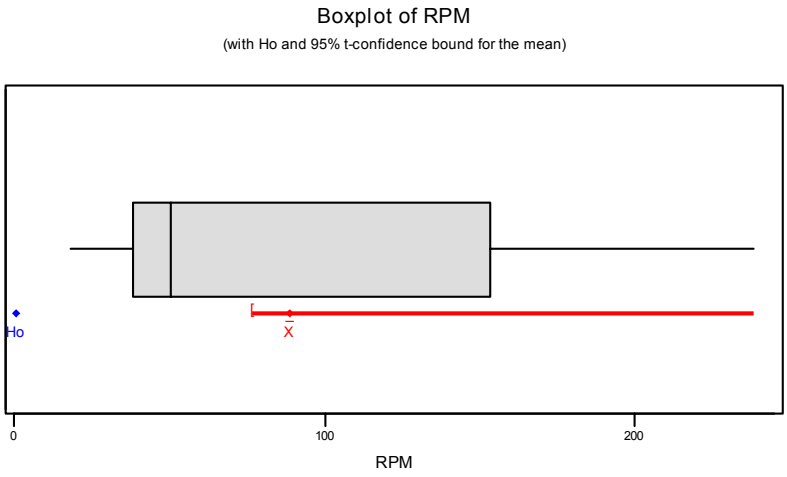

Fig. 6: Box plate of RPM.

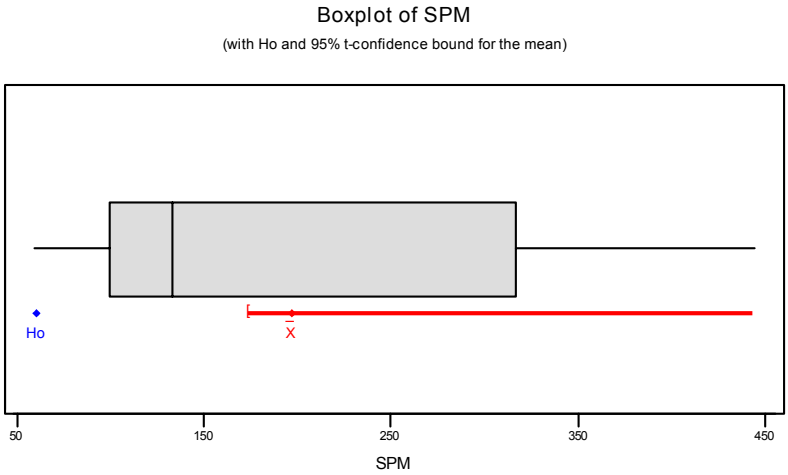

Fig. 7: Box plate of SPM.

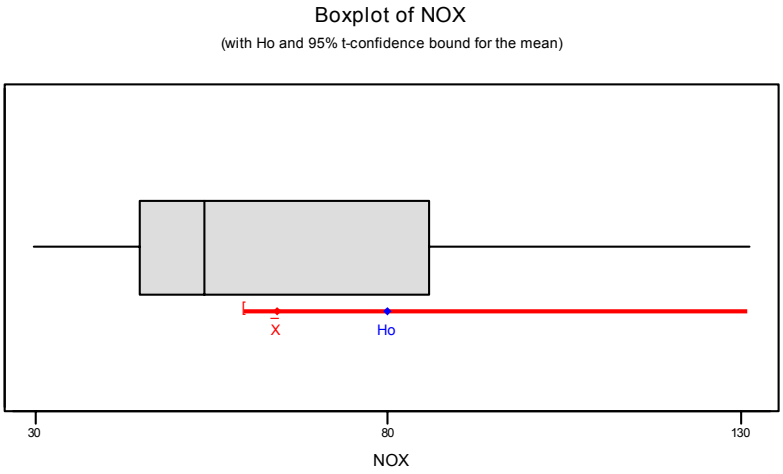

Fig. 8: Box plate of NOx.

disorder (COPD). The maximum number of patients is for asthma during the winter season of 2010. In fact, all the diseases affected the citizens to the greatest in the winter of 2010, a few months after the ban on old vehicles was imposed, showing that the ban has failed to mitigate the air pollution effects (Table 4).

Analysis of variance (ANOVA) of the four parameters: The ANOVA of the four parameters has been performed to see whether their levels differ significantly or not from the average levels in the three seasons. It was found that all the four parameters differ significantly from their average values for all the three seasons of the three years.

Fig. 9: Box plate of SOx.

Box plots of the SPM, RPM, SOx and NOx: Four box plots were obtained by calculating the p-values for all the four parameters. It was found that the average levels of SPM and RPM differ significantly from their standard values but SOx and NOx do not differ much from the standard values (Figs. 6, 7, 8, 9).

Kolkata is among the most polluted cities of the world. The major reason for the highly increased air pollution load in the city during the 2000-2008 period was huge increase in the number of private taxis, buses, autos, cars, etc. The city also has an additional problem of having very old vehicles.

The Supreme Court banned all the vehicles greater than 15-year old from plying on roads of Kolkata, which was made effective from August 1, 2009. About 32000 auto rickshaws, 2500 private buses, 6000 taxis, 500 mini buses and 22,000 trucks were banned. However, there was no guarantee that the vehicles less than 15-year old are not going to increase air pollution.

In order to investigate the air pollution load in Kolkata, an year-wise comparison of the four air pollution parameters SPM, RPM, NOx and SOx was undertaken considering three periods of before the ban, during the ban and after the ban. The season-wise comparison showed that the winter season of 2010 had the highest value of particulate matter, while monsoon of 2010 had the lowest values for the same. The season-wise comparison showed that winter season for all the three years has highest concentration of all the four parameters, while the monsoon season the lowest values in all the three years.

A few questionnaires were also used for survey in the three hospitals to find whether air pollution has caused any disease among the citizens. The doctors gave a list of patients who were suffering from diseases caused due to air pollution. The number of patients was typically found to be the highest in the winter season of 2010 with a total of 157 patients. This is really striking as the highest number of patients seems to have appeared when the ban on old vehicles has been imposed in Kolkata. This really makes the ban an unsuccessful one. The other two seasons, summer and monsoon, also show that the ban has not been that much successful as the number of patients after decreasing for the year 2009 after the ban for some time, increased again in the next year 2010.

The air pollution is a major cause for various kinds of diseases particularly the respiratory diseases like asthma, restrictive lung disorder and chronic obstructive pulmonary disorder, lung cancer, and cardiac diseases (Ghose et al. 2005). These diseases have taken a toll on the citizens maximum during the winters (2010) and the minimum during the monsoons (2009). This is probably due to the high concentration of the particulate matter present in the atmosphere during winter, and lowest in monsoon. The effect of the ban could not be understood properly on these patients as the study has to be on a longer term basis. The air pollution can also cause mutations, which are time consuming hence, the effect of air pollution was seen during the time of 2008 but could not be analysed properly after the ban as the time span was short.

The pulmonary diseases are common outcome of the high levels of air pollution (Seaton 1995). The particulate matter concentration is generally high in the atmosphere and if particles are of the respirable size (< 0.65μ), then they get respired into the lungs and get deposited inside the same. Thus, hindering the proper activity of the lungs like gas exchange in the alveoli or the release of surfactant type of chemicals by bronchioles, which lead to various kinds of respiratory disorders. In asthma, the spastic contraction of the bronchioles occurs during expiration. This occurs due to the

hypersensitivity reactions caused by air pollutants that act as allergens and the particulate matters get deposited on the bronchial walls leading to the improper release of the surfactants (DPPC-dipalmitoyl phosphatidyl choline) thereby leading to improper contraction and relaxation of the muscles.

In the restrictive lung disorder, the particulate matters get deposited in the alveoli leading to improper gas exchange. The lung tissues do not get proper oxygen supply and the carbon dioxide content increases which leads to improper cell functioning and finally lung failure.

COPD is mainly comprises of two diseases, chronic bronchitis and emphysema. The particulate matter and other primary air pollutants cause the air passage to get constricted and the destruction of the alveoli and terminal bronchioles. These two diseases are the result of inflammation and tissue degradation (Russell Michael 2006). The NO_2 is a potent agent for PAN (peroxy acetyl nitrate) formation. It is a powerful respiratory irritant, lachrymator and mutagenic in nature (Lui et al. 1999). The peroxy acetyl nitrate, if inhaled, leads to destruction of the tissues of lungs leading to inflammation and the respiratory distress.

The particulate matters, SOx and NOx cause an enhanced coagulation or thrombosis. They propel arrhythmia and acute arterial vasoconstriction due to deposition of particulate matter in the blood vessels leading to atherosclerosis. This leads to improper functioning of heart and its related vascular system (Brook et al. 2004). This leads to cardiovascular diseases. This may lead to a fatal state of myocardial infarction. The SOx and NOx are also the main causative agents for the lung cancer apart from few particulate matters like lead, cadmium, etc.

Our main goal was to determine the effectivity of the old vehicular ban on the streets of Kolkata. It was found that after the ban there was a dip in the levels of SPM, RPM, SOx and NOx. But with time, as more and more vehicles entered the roads of Kolkata and the people became forgetful of the ban, the levels of these four air pollutants increased and are now showing a rise. The increasing pollution can be controlled if the ban is again imposed strictly. The West Bengal Pollution Control Board conducts air pollution surveys regularly and launched the ICEF (India Canada Environment Facility) project to reduce SPM and RPM levels (Chakrabarty & Bhattacharya 2004). Further, decentralization of office areas, improvement of road conditions, regulation of traffic and proper implementation of the ban on polluting vehicles is mandatory to improve air pollution levels in the city. The greater the government promotes the usage of eco-friendly fuel, the better it will be for the air of Kolkata. The government has to strengthen its Inspection and Maintenance (I&M) of public and private transport. The WBPCB and CPCB (Central Pollution Control Board) are working hard to improve the air quality, but ultimately, it is duty of citizens to abide by the rules if we have to breathe a cleaner air.

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