



# Hotspot Detection, Traffic Pollution and Asthma Incidence in and around Kolkata, India

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## Abstract

Urban air quality in megacities like Kolkata is found to be critical. An analysis of ambient air quality in Kolkata is prepared where the presence of  $\text{NO}_2$ ,  $\text{PM}_{10}$  pollutants' annual average concentration and temporal fluctuation are studied. Out of a total of 17 ambient air quality monitoring stations operating in Kolkata, five fall under the critical category, in addition the remaining 12 locations fall under the high category of  $\text{NO}_2$  concentration. The causes towards the high concentration of pollutants in the form of  $\text{NO}_2$  and  $\text{PM}_{10}$  was identified as vehicular emission (51.4%), followed by industrial sources (24.5%) and dust particles (21.1%). There was evidence of an impact of pollution on a health assessment through a structured questionnaire at Allergy and Asthma Research Centre, Kolkata as well as Missionaries of Charity, Kolkata outdoor patient dispensaries among 500 participants. It shows that respondents with respiratory diseases (85.1%) have outnumbered waterborne diseases (14.9%). Although the pollution level was critical, only 49.3% of the respondents have felt that outdoor (air) pollution has affected their health.

**Keywords:** Air quality; Hot spot; Kolkata; Respiratory health

## Introduction

This century has seen the increased popularity of respiratory-related health illnesses with the poor air quality is a significant cause for illnesses [1,2]. Air pollution is strongly associated with respiratory disorder aggravation. Traffic pollution might be playing a key role. A number of studies also convey that not only a single pollutant is responsible for causing respiratory-related health problems, but also a group of them ( $\text{SO}_2$ ,  $\text{NO}_2$ , ozone ( $\text{O}_3$ ), along with Particulate Matter (PM)) [3,4]. Most, but not all, paediatric epidemiological studies found a consistent but small effect of long-term exposure to car traffic or its emissions on respiratory symptoms on lung function [5-11]. A huge cross-sectional study using pollutant contact calculated on a 1-km<sup>2</sup> grid in Kolkata, West Bengal found increased cough and bronchitis. The relationship between allergy and traffic exposure is less consistent. Nevertheless a number of studies found no increase in allergy with measured traffic exposure.

The objectives of this research are to:

(1) assess the asthma rates in and around Kolkata,

(2) highlight significance of asthma together with its relation to spatiotemporal changes in traffic air pollution,

(3) interpolate and model the air quality data concerning the Particulate Matter ( $\text{PM}_{10}$ ) also  $\text{NO}_2$ . Analyse the statistical association of asthma to traffic air pollution.

## Materials and Methods

### Study Population

Between May 2018 and March 2020, we conducted a survey for predictability of childhood asthma with traffic air pollutants in Kolkata and its surroundings. The Ethics Committee of the NGO Allergy and Asthma Research Centre, Kolkata approved the study. An English version of the questionnaire combining a standard one designed by the International Study of Asthma and Allergies in Childhood (ISAAC) with some changes to address the housing and cultural description of Kolkata it was administered to collect information on health status and probable contact to the outdoor environmental factors of children and family members.

A total of 500 questionnaires were randomly distributed to the atopic parents with children below 6 years of age and who are not suffering from any asthmatic disorder. Out of this 195 were

positive respondents. Asthma data in this study was collected from outdoor department of Allergy and Asthma Research Centre, Kolkata and Missionaries of Charity, Kolkata. Ordinary questionnaire assessed demography, literacy, standard of living with socioeconomic variables, basic environmental conditions, confounding factors, nature and types of health burdens as well as assess the attitude towards health care facilities. Assessing the air pollution condition of different areas of Kolkata and correlating that with the incidence of respiratory disorder (Figure 1).

### Exposure Assessment

Mainly two pollutants, Nitrogen Dioxide (NO<sub>2</sub>), and Particulate Matter <sub>10</sub> mm in diameter (PM<sub>10</sub>) were selected to represent ambient air pollution in Kolkata where, NO<sub>2</sub> traffic related air pollution, and PM<sub>10</sub> as a surrogate of complex mixture of air pollutants. Average daily concentrations of PM<sub>10</sub> and NO<sub>2</sub> were obtained from 17 Kolkata municipal air pollution monitoring stations on a seasonal and yearly basis.

### Geo-coding of Patient Data

Data were put in Microsoft access software and segregated location wise furthermore analysed using MapInfo GIS software. The first step in the analysis process is geo-coding, which assigns patient counts to the corresponding ZIP code. An address locator was formed for ZIP code polygons. On average, there was 90% of geo-coding accuracy for the patient data, the rest of 10% was an slip because of the absence of ZIP code information. Later, quantitative choropleth mapping technique showed the number of patients by ZIP code. Street line geo-coding used as a foundation address database to match the addresses of incidence of the disease and to collect the traffic count in order to correlate the data with number of cases.

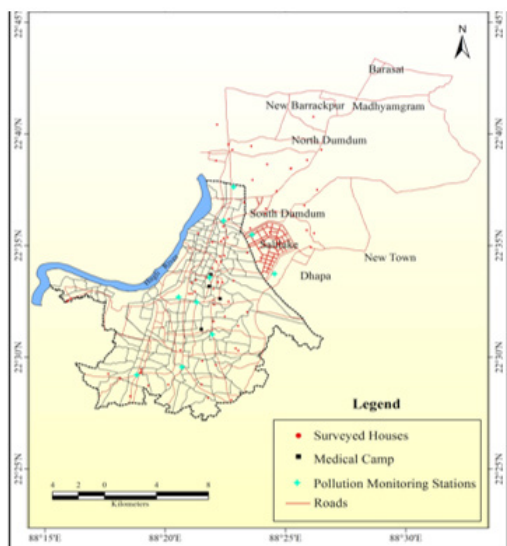


Figure 1: Assessing the air pollution condition of different areas of Kolkata.

### Investigation of asthma patients using hotspot analysis

Hotspot Analysis uses vectors to recognize locations of statistically significant hot spots and cold spots in my data by aggregating points of occurrence into converging points that are in proximity to one another based on a calculated distance. The analysis groups feature when similar high (hot) or low (cold) values are found in a cluster.

In order to measure the spatial-temporal auto correlation's degree for spatial-temporal non stationary series, the new Temporarily Descended Global and Local Spatial-Temporal Moran's Indexes (TDGSTI and TDLSTI) are proposed. The Moran's scatter plot, which discloses the spatial-temporal cluster pattern's characteristics and pattern's change, is extended. TDGSTI is found to reveal the auto-correlation level of spatial-temporal objects. For a positive TDGSTI, the higher the TDGSTI, the higher the auto-correlation level, and vice versa. TDGSTI is closely related to time-scale s, time-lag hand spatial-temporal weight matrix. For, TDGSTI is significant, while for and , TDGSTI is insignificant. TDGSTI has clear potential to test the spatial-temporal auto-correlation's degree for spatial-temporal non-stationary series in other research fields.

The increased energy consumption (petroleum and coal) from the transport and industrial sectors and added capacity of power plant production contributed to enhance the level of NO<sub>2</sub> in EMR during this period. Continuous assessment of Air quality index of two oldest air monitoring stations was done (Figure 2). This was correlated with the incidence of asthma in the study area.

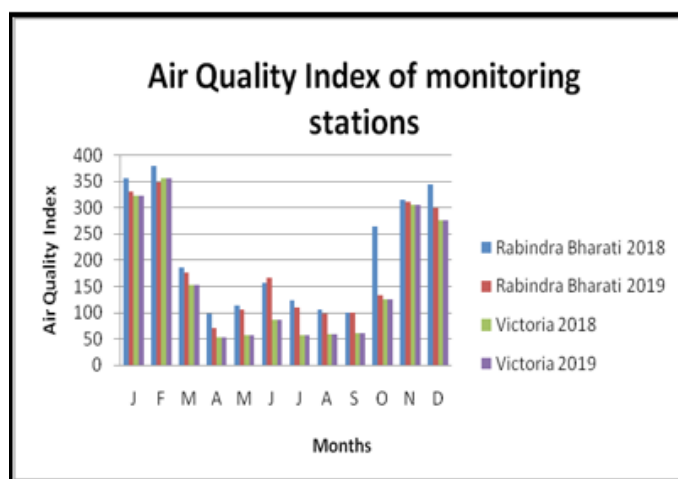


Figure 2: Air Quality index of monitoring stations.

## Discussion

### Demographic Set up

The city of Kolkata has a very high population density

of 24,000 people per square kilometre. It is as a mega-city and covers an amount of surface area that comes to a total of 205.00 square kilometres. Spatial analysis indicated that asthma related patients have increased geographically and large numbers are found concentrated around the road crossings and near heavy congested areas. Road transport accounts for a significant portion of air pollution in the city, causing serious pollution problems like carbon monoxide and smog (Figure 3). Traffic fumes contain harmful chemicals that pollute the atmosphere.

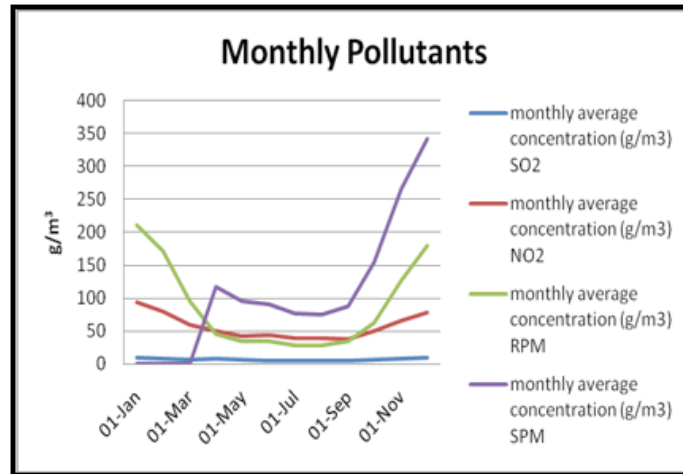


Figure 3: Monthly Pollutants.

Abundance of poorly maintained vehicles, use of petrol fuel and poor controlling is making transportation the major air-polluting sector. A key driver in addressing air pollution issues is the burden it has on human health. Nevertheless, we see some important correlations. In general terms, the death ordinarily from air pollution is higher in countries that have a higher level of pollution (Figure 4).

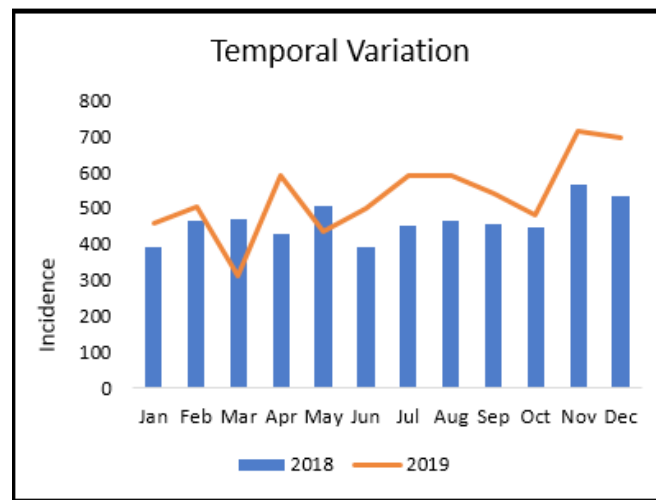


Figure 4: Temporal Variation.

Monthly change in incidence of respiratory problems show a high during the winter months in addition to there is a marked increase of disease over the years. To know the concentration of pollutants in the ambient air along with its varying nature, a trend analysis is conducted for the years ranging from 2008 to 2019 with the criteria pollutants; namely, NO<sub>2</sub> and PM<sub>10</sub> with a record of number of registered vehicles in Kolkata (Figure 5). The trends show a strong correlation between number of vehicles along with the recorded pollutants.

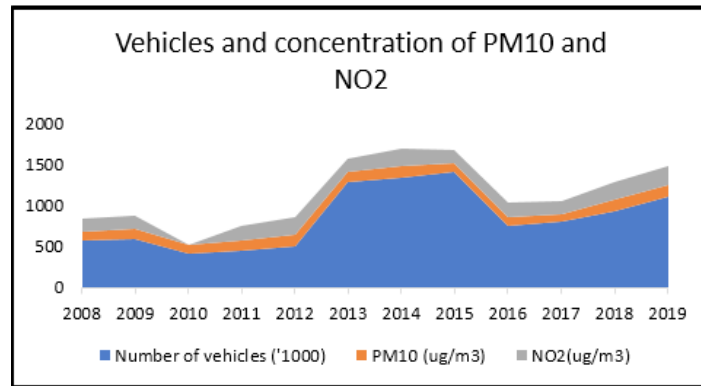


Figure 5: Vehicles and concentration of PM<sub>10</sub> and NO<sub>2</sub>.

I analysed spatial dependency of traffic state based on spatial auto-correlation method, which show that existing association in space furthermore urban road network traffic state goes hand in hand and urban traffic state is unstable in space and is related to land use. Further, deviation trend analysis show that urban traffic state is influenced by road network structure, and it can also quantitatively analyse the influence range, which is useful to discover hot spot in urban traffic, such as traffic congestion. Traffic data from the study area during 2018-2020 is used to examine the dynamic space-time pattern of high traffic and incidence of respiratory disorder, and all cases were geo coded at a ward level. Inverse Distance Weighting (IDW) is used to interpolate and predict the pattern of high traffic flow in the city area (Figure 6). Help of Moran's I Index (Moran's I) statistics is undertaken to evaluate auto-correlation in traffic pattern's spatial distribution and to test how houses with reported incidence were clustered or dispersed in space. Getis-Ord Gi\*(d) was used to identify the hotspot coupled with cold spot areas within the study site.

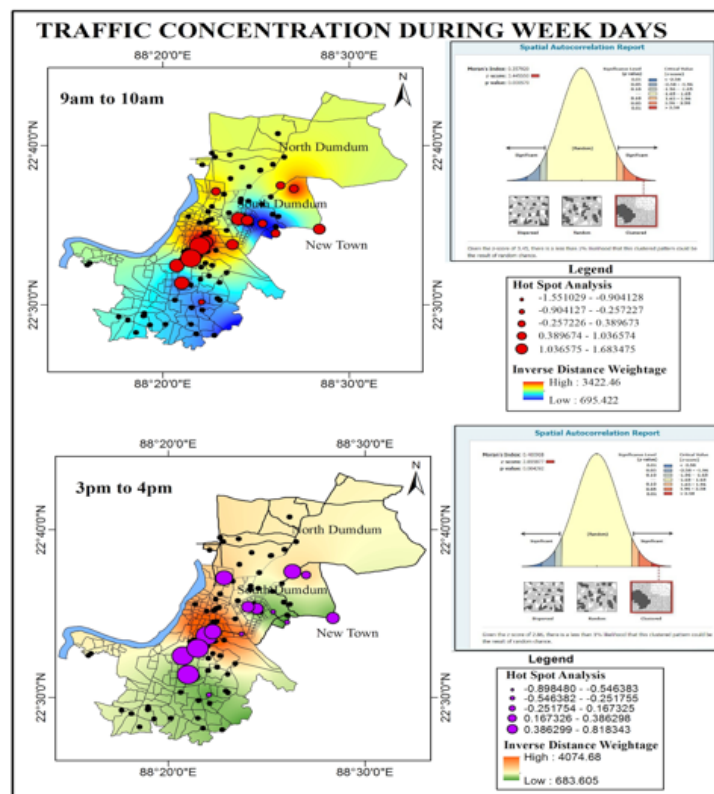


Figure 6: Traffic concentration during week days.

Moreover, this study reveals the severity of the pollution level exist in these regions in a health and ecological point of view. Also it examined the extent of dispersion of NO<sub>2</sub> beyond the city. It indicate need of more pollution monitoring sites over rural regions. The trend analysis of each region represents the tendency of collective emissions from all the districts come under that particular region in addition they showed an increasing trend in all the regions. There are some differences in statistics obtained from the previously reported studies, because of the cluster of districts considered here are not the same. But the general trend reported here for various regions are in agreement with the previously published results for the same location.

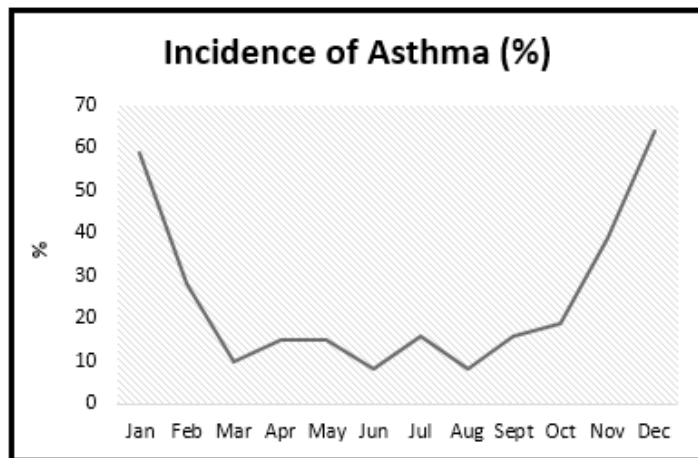


Figure 8: Incidence of Asthma (%).

### Statistical Analysis

We conducted several sensitivity analyses to examine the strength of our findings on the incidence. In the incidence study, we included crude analysis, with adjusting background air pollution, use of continuous variables for personal exposure levels instead of categorisations, use of distance from heavily trafficked roads (<50 m, 50 m to <100 m, 100 m or more), history of attendance in nursery school/kindergarten, parent with asthma, house structure, keeping pets, familial smoking habits, feeding method during the first 3 months of life. There was no significant association between exposure to traffic-related air pollution and the development of asthma from 1½ to 3 years of age. On the other hand, exposure to traffic-related air pollution was significantly associated with the prevalence of wheezing at the age of 1½ years as well as the persistence of asthmatic symptoms (between 1½ and 3 years of age).

### Conclusion

In this population based survey, high vehicle traffic close to the home has a positive effect of respiratory complaints, such as cough, wheeze along with current asthma indication in children. An association between exposure to heavy traffic and allergic sensitisation additionally exposed to ETS was also noticed. Few methodological limitations were faced in this study. The city of Kolkata provided traffic count for major crossings only. This may have led to some misclassification of traffic exposure. Children living close to road crossings with particular lifestyle condition makes it difficult to differentiate between a possible direct exposure to traffic and other confounding variables. These families were of lower SES and their children were more often exposed to ETS. No clustering of outcomes was observed with local socioeconomic characteristics of the city areas. The advantages of this study are

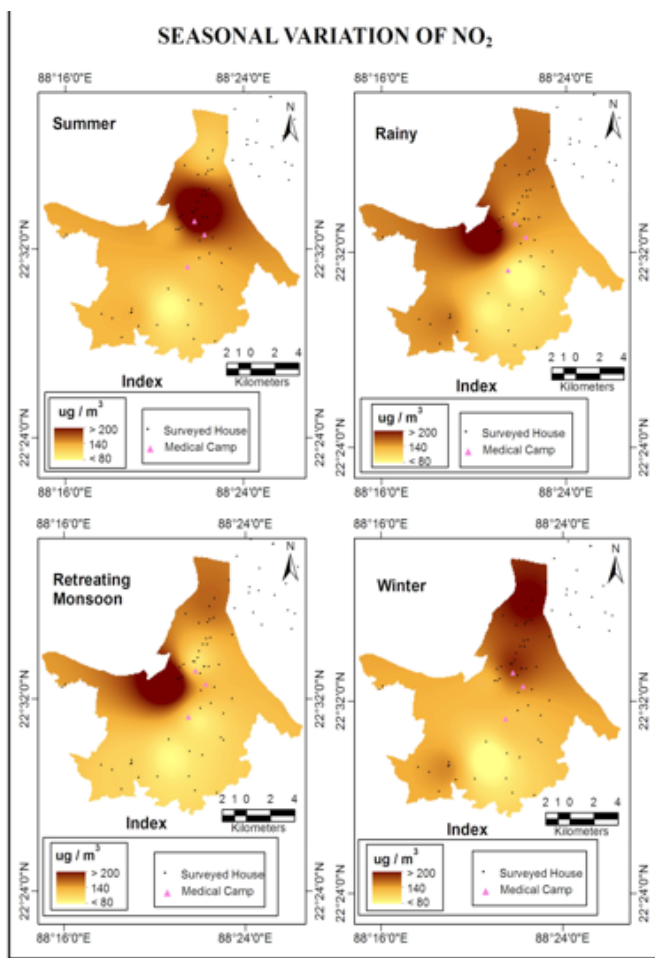


Figure 7: Seasonal variation of NO<sub>2</sub>.

Seasonal variation of NO<sub>2</sub> is shown. Winter has a high concentration of NO<sub>2</sub> which is above the permissible limit in more areas of Kolkata than in other seasons (Figure 7). This show a positive impact of higher incidence of respiratory problems (Figure 8).

the large number of subjects, population based design and the GIS assessment of exposure using traffic counts and measurement of air pollutants.

Two fascinating observations clearly seen are high traffic exposure associated with cough, wheeze among children and with history of atopic sensitization exposed to ETS. Similar association with outcomes were seen for traffic related air pollution levels. Secondly when streets >50 m from home are included in exposure assessment traffic effect was diluted. A large congestion of traffic was reported at street of residence and not at the zone of it. There is no significant effect on allergic sensitization from pollution exposure. This clearly indicates that other confounding parameters like socioeconomic characteristics associated with place of residence play a very important role in this study. Children living in areas with low traffic exposure display a very strong atopic influence. It is also possible that increased outcome occurrences are ascribed to differences in lifestyle along with living conditions associated to poverty and low socioeconomic status rather than to traffic coverage itself.

## Acknowledgement

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