Association of Environmental Factors, Prevalence of Asthma and Respiratory Morbidity in Mumbai: Need of a Public Health Policy

Amita Athavale1, Hariharan Iyer2, Aditi D Punwani3, Jeenam J Shah4, Gita Natraj1, Jairaj P Nair4, Rakesh Kumar5, Lakshmi R Menon6, Aparna N Iyer4, Sagar J Raiya2

Abstract

Objectives: To study the association between environmental factors, prevalence of asthma and respiratory morbidity in relation to air quality levels in a mega city. To study modifiable environmental factors in people with diagnosed asthma and increased respiratory morbidity.

Methods: Cross sectional survey of population (N-3233) from 6 localities near air quality stations was done to study prevalence of asthma and respiratory morbidity (n-1006) followed by case control study of environmental factors by air sampling to study biological contamination.

Results: Univariate analysis was performed to study effect of various risk factors. Respiratory morbidity was significantly high in areas with high SPM levels. Odd's ratio was 10.3 for wheezing, 9.16 for cough, and 12.6 for breathlessness. Presence of biological contamination of air [bacterial spores] was associated with respiratory morbidity with odds ratio of 2.2 in areas with open drainage system. Pigeon droppings were found to be the source of fungal spores and associated with respiratory symptoms with odds ratio of 1.8.

Conclusion: Respiratory morbidity significantly rises in areas with high particulate matter levels and biological contamination of air. Identification of environmental risk factors in different localities will be useful for undertaking specific mitigation measures at local level as a public health measure.

Editorial Viewpoint

• Indoor and outdoor environmental factors are directly related to respiratory health.
• This study assesses air quality in Mumbai in relation to respiratory morbidity.
• Study finds high morbidity in areas with high particulate matter levels and biological contamination.

Background

Indoor and outdoor environmental factors are linked to asthma morbidity. Outdoor air pollution can cause exacerbations of pre-existing asthma, which has been supported by numerous evidences.1,2 Correlation of environmental factors with asthma and rhinitis was studied in Tulsa (USA) where Ambrosia pollen and other environmental variables, including Ozone levels, were significantly correlated with asthma and rhinitis symptoms.3 Associations between pollutants, pollen counts and asthma related hospital admissions have been studied in an Indian Metropolis.4 Prevalence of asthma in Mumbai was reported to be 3.5% in the study by Chawgule et al.5

Megacity Mumbai has rising levels of suspended particulate matter [SPM] due to construction activities, bakeries, hotels and open burning (36.7%); point sources like industries (28.1%); line sources like road dust and vehicular sources (35.3%).6 Disease affected life years [DALY] lost due to non-communicable respiratory disorders related to indoor and outdoor air pollution are 400-1100 annually per 100000 persons.7

1Professor, 2Speciality Medical Officer, 3Registrar, 4Assistant Professor, Seth GS Medical College and KEM Hospital, Mumbai, Maharashtra, 5Scientist G and Head, National Environment Engineering Research Institute (NEERI), Mumbai, Maharashtra; 6Senior Scientific Officer, Seth GS Medical College and KEM Hospital Mumbai, Maharashtra
Received: 24.05.2016; Accepted: 03.04.2017
Table 1: Area wise distribution of age, gender and confounding factors

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20</td>
<td>11 (5.1)</td>
<td>16 (8.2)</td>
<td>7 (4.6)</td>
<td>5 (6.4)</td>
<td>6 (5.9)</td>
<td>20 (7.5)</td>
</tr>
<tr>
<td>20 – 40</td>
<td>38 (17.6)</td>
<td>41 (21.1)</td>
<td>34 (22.4)</td>
<td>29 (37.2)</td>
<td>35 (34.7)</td>
<td>100 (37.7)</td>
</tr>
<tr>
<td>41 – 60</td>
<td>71 (32.9)</td>
<td>73 (37.7)</td>
<td>62 (40.8)</td>
<td>40 (51.3)</td>
<td>47 (46.5)</td>
<td>95 (35.9)</td>
</tr>
<tr>
<td>61 – 80</td>
<td>96 (44.4)</td>
<td>64 (33)</td>
<td>49 (32.2)</td>
<td>4 (5.1)</td>
<td>13 (12.9)</td>
<td>50 (18.9)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>84 (38.9)</td>
<td>77 (39.7)</td>
<td>56 (36.8)</td>
<td>28 (35.9)</td>
<td>48 (47.5)</td>
<td>104 (39.2)</td>
</tr>
<tr>
<td>Female</td>
<td>132 (61.1)</td>
<td>117 (60.3)</td>
<td>96 (63.2)</td>
<td>50 (64.1)</td>
<td>53 (52.5)</td>
<td>161 (60.8)</td>
</tr>
<tr>
<td>Confounding factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>6 (2.8)</td>
<td>12 (6.2)</td>
<td>5 (3.3)</td>
<td>1 (1.3)</td>
<td>5 (5)</td>
<td>6 (2.3)</td>
</tr>
<tr>
<td>Fuel</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4 (4)</td>
<td>6 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Occupation</td>
<td>1 (0.5)</td>
<td>1 (0.5)</td>
<td>-</td>
<td>1 (1.3)</td>
<td>1 (1)</td>
<td>5 (1.9)</td>
</tr>
<tr>
<td>Ventilation</td>
<td>-</td>
<td>1 (0.5)</td>
<td>-</td>
<td>2 (2)</td>
<td>85 (32.1)</td>
<td></td>
</tr>
<tr>
<td>Prevalence of asthma</td>
<td>9 (4.16)</td>
<td>6 (3.09)</td>
<td>5 (3.28)</td>
<td>2 (2.56)</td>
<td>4 (3.96)</td>
<td>4 (1.50)</td>
</tr>
</tbody>
</table>

All values numbers (%)

Aims and Objectives

- Determine prevalence of respiratory morbidity and asthma in relation to air quality levels in a mega city.
- Study the association of environmental factors - both organic and inorganic - on respiratory morbidity and asthma.
- Propose control measures to reduce respiratory morbidity

Material and Methods

Data pertaining to six fixed air quality monitoring stations from air quality Research Laboratory (MCGM) was received monthly by Environmental Pollution Research Centre, a respiratory morbidity health survey unit at tertiary care Pulmonary medicine department (Graph 1). Suspended Particulate Matter (PM10) levels are increased in five out of six areas in Mumbai city. Cross sectional Questionnaire survey from six localities within 1 km radius from air quality monitoring stations was done. ‘Institutional Ethics Committee’ Seth GS Medical College and KEM Hospital (EC/OUT/947/11, 10th December 2011) approved the study.

Information sheet regarding the study was circulated amongst residents from selected localities by community development officers. Census population consisted of 3233 subjects from 1174 families. Total 1006 subjects consented to participate from the 6 areas.

Localities chosen were from middle and lower income group and for socioeconomic purpose were comparable. There are differences in surrounding area and type of housing. Borivali has middle income group, housing consisting of bungalows and buildings and is surrounded by greeneries (National Park). SPM levels in this area are <200 micrograms per cubic meter. Khar and Andheri are western suburbs had middle and low income group people residing in buildings. Maravali and Bhandup are eastern suburb, lower income group with open drainage system with squatter settlements and chawls. Maravali is close to industrial area. Worli, situated in central Mumbai has middle income group residing in buildings.

In Phase one validated IUATLD [International Union Against Tuberculosis and Lung Diseases (1984)] Asthma and Respiratory Morbidity questionnaires was distributed in 3 regional languages as per educational background of participants.

Data obtained was analyzed on SPSS version 19 and subjects having physician diagnosed asthma, or respiratory symptoms of cough, breathlessness, wheezing were studied for contamination of their outdoor and indoor environment for organic dust, pollens, fungi, and bacterial spores.

Phase II comprised case control study in subjects with physician diagnosed asthma, increased respiratory morbidity and age matched controls from neighborhood. To study relation of asthma with pollens, pollens were
Our results show that prevalence of asthma was 1.50 to 3.40% (Table 1).

Active air sampling of indoor and outdoor air for bacteria and fungi was done using the Air Sample System LA002 [Hi Media, India] based on centrifugal impaction principle. The isolates were identified up to genus level.

**Observations and Results**

A total of 1006 subjects were studied. The total asthma prevalence rate of physician diagnosed asthma was 1.5 to 4.16% (mean - 2.98%) (Table 1). Our results show that prevalence of asthma does not vary with outdoor air quality. Whereas the symptom triad of cough, breathlessness and wheezing/chest tightness together correspond to ‘asthma suspects’ [though they had never been diagnosed by a physician as asthmatics],* tends to increase with a rise in SPM levels.

5.4% of the cases belonging to age group > 60 years had asthma which was significantly more compared to age group < 60 years. There is a trend that as age increases proportion of asthma cases significantly increase. There is a direct relationship between age and prevalence of asthma.

Significant association was seen between SPM levels [air quality] and respiratory symptoms (Table 2).

10.6% and 42.6% of the cases with SPM level 200 – 400 micrograms per cubic meter (µg/m³) and >500 µg/m³ respectively had cough which was significantly more as compared to 6.9% of the cases with SPM level <200µg/m³.

4.2% and 22.8% of the cases with SPM level 200 – 400 µg/m³ and >500 µg/m³ respectively had wheezing which was significantly more as compared to 2.8% of the cases with SPM level <200 µg/m³.

10.6% and 42.6% of the cases with SPM level 200 – 400 µg/m³ and >500 µg/m³ respectively had breathlessness which was significantly more as compared to 5.6% of the cases with SPM level <200 µg/m³.

It was observed that Maraval area which has highest SPM levels also has highest respiratory morbidity. Borivali where air quality was well within normal limits had lowest respiratory morbidity. Remaining areas had SPM levels beyond permissible limits.

The fuel used for house hold purposes were analyzed. A total of 10 (1%) used kerosene, 987 (98.1%) used LPG and 9 (0.9%) used electricity for cooking. Thus a confounding factor for indoor biomass fuel exposure was eliminated (Table 1).

Aerobiological factor monitoring was carried out in 30 symptomatic cases [asthma, cough, wheezing, shortness of breath] and 30 controls. Commonest varieties of pollen found were coconut [14.1%] and China rose [7.8%].

### Table 2: Association between SPM level and symptoms among study cases (n=1006)

<table>
<thead>
<tr>
<th>SPM level</th>
<th>Total cases</th>
<th>Cough</th>
<th>Wheeze</th>
<th>Breathlessness</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;200</td>
<td>216</td>
<td>15 (6.9)</td>
<td>6 (2.8)</td>
<td>12 (5.6)</td>
</tr>
<tr>
<td>200-400</td>
<td>689</td>
<td>73 (10.6)</td>
<td>29 (4.2)</td>
<td>73 (10.6)</td>
</tr>
<tr>
<td>&gt;500</td>
<td>101</td>
<td>41 (40.6)</td>
<td>23 (22.8)</td>
<td>43 (42.6)</td>
</tr>
</tbody>
</table>

By Chi Square test; P = 0.001; *Significant; All values numbers (％)

### Table 3: Associations between diagnosis and aspergillus among study cases (n=60)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Aspergillus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No growth</td>
</tr>
<tr>
<td>Control (N = 30)</td>
<td>23 (76.7)</td>
</tr>
<tr>
<td>Asthma (N = 16)</td>
<td>15 (93.7)</td>
</tr>
<tr>
<td>Symptomatic (N = 14)</td>
<td>8 (57.2)</td>
</tr>
</tbody>
</table>

P value 0.061 *0.005 (NS)

By Chi Square test; NS = Not Significant; *Significant; All values numbers (％)

35.7% of the symptomatic cases showed growth of aspergillus which was significantly more as compared to 3.3% of the cases among control group and 6.3% of the asthmatic cases (Table 3).

Bacterial CFU in asthma were 3471.67 which were high as compared to 213.47 and 174.36 in control and symptomatic subjects respectively which is statistically significant (Table 4).

13.3% of the cases with family history of respiratory illness had asthma which was significantly more as compared to 2.5% of the cases who did not have any family history.

In area with open drainage system, biological contamination of air with higher bacterial spore count showed increased symptoms of cough, wheezing, and chest tightness.

During case control study it was observed that a diagnosed case of asthma presented with symptoms suggestive of secondary infection (pneumonia) with an acute exacerbation. His locality was abutting an open sewage drain. On sampling the outdoor and ground floor room air, >100000 CFU of Gram positive cocci were grown while on the mezzanine floor the counts were significantly less [1000 CFU].

3 females aged 52, 68, 80 who spent more than 10 hours indoor, had exposure to pigeon droppings from outdoor air and had complaints of repeated exacerbations of...
wheezing and breathlessness. Two out of the 3 were diagnosed to have hypersensitivity pneumonitis and 1 had exacerbation of asthma. Aerobiological monitoring showed growth of Aspergillus fungus from indoor air sampling. None had wet walls or visible mould indoors. Pigeon nesting was present around their residential areas.

This coincides with our statistical analysis that fungi and their products are the most positively associated with asthma [46.9%], cough [23.4%], wheezing [46.9%] and shortness of breath [46.9%]. In most of the cases where Aspergillus species were cultured, pigeons were reported to be a nuisance by the subjects.

Statistical analyses were performed using SPSS software version 19. The results were expressed as mean with standard deviation if variables were continuous, and as frequency with percentage if variables were categorical. The Student t test for comparing continuous variables and chi-square test to compare proportions among groups were used.

Univariate analyses was performed to study the effect of various risk factors. Odds ratio with 95% confidence Interval were calculated to assess the risk of variables. From the univariate analysis, variables with P values of 0.05 or less were considered significant.

Respiratory morbidity was significantly high in areas with high suspended particulate matter with odds ratio (95% Confidence Interval) were 10.3 (4.0 -26.3) for wheezing, 9.16 (4.7 – 17.7) cough and 12.6 (6.2 – 25.5) for breathlessness.

Presence of fungal spores had odds ratio of 1.8 (1.2 -2.6) with respiratory symptoms and fungal spores from pigeon droppings was found to be the source.

**Discussion**

This study was aimed at identifying association between environmental factors, prevalence of asthma and respiratory morbidity in relation to air quality levels in a mega city. Positive correlations were found between asthma/respiratory morbidity and increasing age and a positive family history, these being the non-modifiable factors.

Areas with open drainage system showed higher bacterial spore counts. In case control study of subjects with diagnosed asthma, colony count of bacterial spores in outdoor air, ground floor air was higher compared to mezzanine floor which indicated importance of bacterial contamination of indoor air from outdoor air.

A storm water system with open channels for the discharge of rainwater exists in most urbanized areas. Unauthorized discharge of domestic wastewater into the system leads to surface water pollution and spreading of pathogens. Solid waste is commonly disposed of in these open channels. This is particularly problematic in many middle- to low-income countries. To avoid blockages and unauthorized discharge of litter or waste-water, open drains can be covered by concrete slabs. Definitive control measure will be closure of open drainage in the locality by civic body for reducing bacterial contamination of air.

Bacterial presence in the airway appears to influence the inception and may affect the activity of asthma. Infectious agents invade airway epithelial cells and cause both edema and leakage of serum proteins. This results in obstruction and wheezing. In addition, an inflammatory response is initiated to control the infection, causing secretion of cytokines and chemokines that enhance airway inflammation.

In our study we found that out of all subjects/samples found to have presence of bacterial growth in their outdoor air samples, 40.5% complained of cough and wheezing and had asthma.

Patankar et al11 used a logistic regression model on the data collected by the Environmental Pollution Research Centre, revealing statistically significant relationship between air pollution and respiratory and cardiovascular outcomes. PM10 and NO2 were identified as critical pollutants.

Allergy to pollen, particularly grass pollen, is associated with the epidemic increase in asthma episodes during the months of May and June. In our study coconut and China rose were found to be the commonest types of pollen.

In atopic subjects, exposure to air pollution increases airway responsiveness to aeroallergens. Pollen grains seem to be a useful model to study the interrelationship between air pollution and respiratory allergic diseases, and in the atmosphere and in the airways an interaction has been observed between pollen allergens and air pollution. Airway mucosal damage and the impaired mucociliary clearance induced by air pollution may facilitate the penetration and the access of inhaled allergens to the cells of the immune system and so promote airway sensitization.

The main hypothesis to explain how allergens trigger auto-reactive responses in humans is that the fungal proteins have significant homology to their human paralogs so that an immune response directed at the fungal protein will also target human counterparts. The reactivity of asthmatic patients to multiple mould allergens could be due to genuine sensitization to a variety of fungi, or it could be due
to cross-reactivity between fungal allergens.

In our study we found that on aerobiological monitoring Aspergillus fungus growth was observed [46.9%] and had strongest correlation with respiratory morbidity and asthma.

Cases of extrinsic allergic alveolitis who reported cough and breathlessness, had reported nuisance from pigeon droppings from surroundings as a trigger factor. Cases of asthma have been reported related to pigeon related allergens from inner city areas from this city. In the city with population density of more than 20000 people per square kilometer overcrowding in squatter settlements and high humidity in coastal city promotes growth of moulds.

Feral pigeons are important epidemiologically, being reservoirs and potential vectors of a large number of microorganisms and source of antigens of zoonotic concern, causing both infections and allergic diseases. Transmission of pathogens to humans occurs via excreta, secretions, or dust from feathers spread into the environment. Thus a direct contact with pigeons can be unimportant. Pigeons breeding and roosting sites host a number of arthropods that may infest humans as bugs, fleas, mites and ticks. The soft tick Argas reflexus are of particular human concern.

Multiple antigens have been extracted from pigeon droppings, feathers, serum, egg yolk and white, crop fluid and gut wall. By cross-absorption, the major antigens were demonstrated in the gamma-globulin fraction of pigeon serum and these had immunological identity with IgA in droppings and on the dust extruded from feathers called ‘bloom’. This consists of inert keratin particles one micron in diameter which carry serum proteins.

Pigeon allergens may play an important role in worsening asthma in certain urban environments containing many pigeons. Considerable amounts of pigeon allergen are present in some urban environments. Such exposure estimates should be very useful in conducting remediation / remedial work and/or health studies in buildings contaminated with pigeon droppings.

In our study of pigeon droppings, Aspergillus fungus was found to be the source and was associated with respiratory symptoms with odds ratio of 1.8.

The “normal” air flora should be quantitatively lower than, but qualitatively similar to, that of outdoor air. The presence of one or more fungal species at significant levels in indoor but not outdoor samples is evidence of an indoor amplifier.

Sufficient evidence supports widespread dissemination of multifaceted, in-home, tailored interventions for asthma; integrated pest management for reducing cockroach allergen;
and combined elimination of moisture intrusion and leaks and removal of moldy items to reduce respiratory symptoms. Even the strongest housing interventions will be hampered in their ability to reduce asthma morbidity if those individuals are exposed to other outdoor pollutants. Hence for environmental control measures for individual patients with respiratory disorders like asthma, COPD, and extrinsic allergic alveolitis cleaner outdoor air is essential. Individual dust control measures are possible indoors provided outdoor air is clean.

An integrated approach to improve air quality by reduction in SPM levels should be undertaken in various sectors like in vehicular sector e.g. reducing fuel adulteration, traffic congestion reduction, standards for new and old vehicles, and higher usage of public transport. In industrial sector approaches like location specific emission reduction, fugitive emission control and area source management for bakeries, construction sites will improve the air quality.

A code for construction, demolition work and road repair work for containment of dust generated during construction activity and solid waste burning in open sites, closure of open drainage. Contents of suspended particulate matter varies from organic (biological contamination) to inorganic dust.

Public and patient awareness and measures to control zoonotic respiratory infections should be implemented as a public health measure.

Sustained efforts to reduce particulate air pollution in megacity Mumbai will improve lung health of citizens and lower health care costs.

Conclusion

There is a concrete relationship between the organic constituents, high PM10 and increased respiratory morbidity in the population studied. Though the incidence of physician diagnosed asthma remained unchanged in all the 6 areas, the symptom triad [cough, breathlessness, wheezing/chest tightness] defining ‘asthma suspects’ had a positive correlation with the increase in SPM (PM10) levels (Figure 2). These findings call for public health measures regarding reduction in SPM.

The study emphasizes the role of environmental monitoring in identification of triggers. In thickly populated megacities advisory can be issued regarding closure of open drainage to reduce bacterial contamination of air. Identifying local sources of allergens like pigeon dust related fungus requires methods to control bird infestation with fungi like ‘Aspergillus’.

An integrated approach for improving lung health requires control of modifiable environmental factors in megacities. Acting together on the basis of coordinated health, environment and development of public health policies, we can strengthen this platform and make a real difference in human well-being and quality of life.

List of Abbreviations

PM10 – Particulate matter less than 10 microns in diameter
SPM – Suspended particulate matter
COPD – Chronic obstructive pulmonary disease.
IgA – Immunoglobulin A
DNA – Deoxyribonucleic acid
LPG – Liquefied petroleum gas
NOx, SOx – Oxides of nitrogen and sulphur
CFU – Colony forming unit

References


