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Assessment of the Health Impacts of $Pm_{2.5}$ on the Lungs (COPD, LC)

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Abstract: ***This study involves the human health risk due to exposure to $PM_{2.5}$ in the State of Uttar Pradesh during the years 2017, 2018, and 2019. Global Burden of Disease (GBD) Portal was used for the values of Burden of Disease for the respective years and location.***
AIR Q+ Software is used for the calculation of the Relative Risk from which Population Attributable Fraction was estimated. By using the values of Attributable Burden of Disease we got the Mortality. From which we came the results that the values of relative risk (central) for Lung Cancer for the years 2017, 2018, and 2019 are 1.575,1.565, and 1.470 respectively, and the relative risk for COPD is 1.705, 1.696, and 1.601 for the year 2017, 2018 and 2019 respectively.
Keywords: Air Pollution, Particulate Matter, $PM_{2.5}$, Health Risk Assessment, Burden of Diseases, Population Attributable Fraction (PAF).

I. INTRODUCTION

With the advent of rising urbanization and modernization, it has been found that the level of air pollution in the cities is also rising. All through the recent few years, levels of smog have risen throughout India resulting in the worsening of air quality and raising global concerns.

One of the most detrimental environmental problems brought on by growth in ambient air pollution. According to the Global Burden of Disease (GBD) and the World Bank (World Bank, 2016), air pollution is the fourth and fifth greatest risk factor for global health, respectively. $PM_{2.5}$ concentrations in the area mostly depend on their energy efficiency. $PM_{2.5}$ frequently contains heavy metals like arsenic, chromium, and manganese.

Frequent exposure to $PM_{2.5}$ can seriously harm human health, which increases the need for medical care and raises the cost of healthcare, placing a heavy financial burden on locals.

PM is a common type of air pollution made up of both solid and liquid particles suspended in the atmosphere.

The mass concentration of particles having a diameter of fewer than 10 microns (PM_{10}) and of particles with a diameter of fewer than 2.5 microns ($PM_{2.5}$) are two often used measures of a PM that are important to health. $PM_{2.5}$, often known as fine PM, includes ultrafine particles with a diameter of fewer than 0.1 micrometers. In most areas of Europe, $PM_{2.5}$ makes up between 50 and 70 percent of PM_{10}. Since PM with a diameter between 0.1 mm and 1 mm can linger in the atmosphere for days or weeks, they are susceptible to long-distance transboundary air movement.

PM is mixture whose physical and chemical properties differ depending on where it is found.

Sulfates, nitrates, ammonium, other inorganic ions like sodium, potassium, calcium, magnesium, and chloride, organic and elemental carbon, crustal material, particle-bound water, metals (including cadmium, copper, nickel, vanadium, and zinc), and polycyclic aromatic hydrocarbons (PAH) are some of the chemicals that make up particulate matter (PM). In addition, PM contains biological elements including allergens and microbial chemicals.

Particles that can be inhaled and are small enough to reach the thoracic region of the respiratory system are included in $PM_{2.5}$.

It is commonly known that inhalable PM has negative health effects.

They result from exposure over both short- and long-term periods of time (hours, days), and they include:

1) Cardiovascular and respiratory morbidity, including worsening asthma symptoms, respiratory symptoms, and a rise n hospital admissions;
2) Mortality from lung cancer, and from cardiovascular and respiratory diseases.

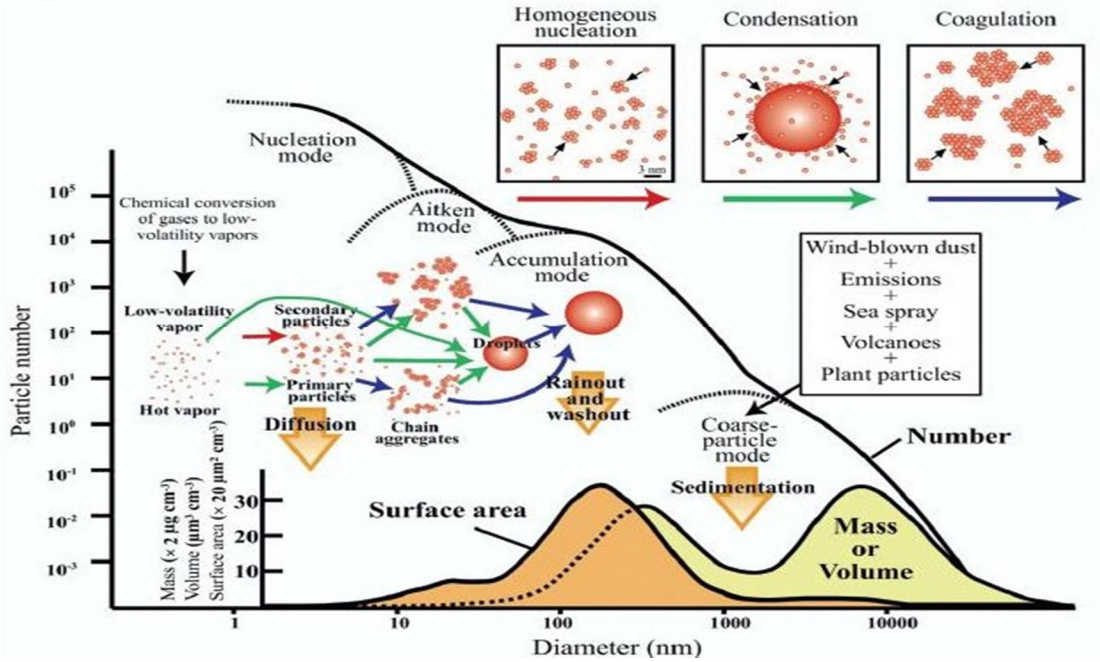


Figure 1 Size Distribution of aerosol particles for various parameters(Buseck and Adachi, 2008)

HEALTH EFFECTS OF $PM_{2.5}$

Asthma, lung cancer, respiratory illnesses, cardiovascular disease, preterm labor, birth defects, low birth weight, developmental disorders, neurodegenerative disorders, mental disorders, and premature death are just a few of the effects of breathing in particulate matter that has been extensively studied in both humans and animals. The fifth-leading risk factor for death is outdoor fine particles with a diameter of fewer than 2.5 microns, which are responsible for 4.2 million annual deaths and more than 103 million years of lost life due to disability. Other psychosocial issues have been connected to air pollution. Particulates can injure tissue directly by invading organs or indirectly through a systemic inflammatory response. Even at exposure levels below the safe air quality limits that have been specified, adverse effects may still occur. The most severe impacts, such as lung cancer and other cardiovascular deaths, are continuously and independently associated with elevated levels of fine particles in the air brought on by anthropogenic particulate air. pollution. The link between particulate pollution and a high number of deaths, as well as other health issues, was originally established in the early 1970s and has since been amply confirmed. According to the Global Burden of Disease Collaboration, PM pollution is thought to lead to between 22,000 and 52,000 fatalities annually in the United States (from 2000) as well as 370,000 premature deaths in Europe in 2005 and 3.22 million deaths worldwide in 2017.

II. OBJECTIVES OF THE RESEARCH

1) Calculation of Relative Risk for Lung Cancer and Chronic Obstructive Pulmonary Disorder (COPD).
2) Calculation of Population Attributable Fraction (PAF) for the disease.
3) Calculation of Attributable Burden (AB) due to Lung Cancer and COPD.

III. LITERATURE REVIEW

This chapter aims to review the various research and studies which were based on the health impact assessment of air pollution.

Pratima Gupta and Ashok Jangid et. al. 2019 conducted research on the Measurement of PM 10, $PM_{2.5,}$ and Black Carbon and assessment of the health effects in Agra. $PM_{2.5}$ had a population-weighted value of 1.7 g m-3. Using the World Health Organization's Air Q+ v.1.2 model, health risk analysis has been carried out (WHO). The particulate matter from nearby combustion sources is the cause of mortality, according to the relative risk factor analysis for the study location. For adults (30 years of age and older), the attributable death rates of $PM_{2.5}$ from chronic obstructive pulmonary disease (COPD), lung cancer, and stroke are 1033, 2068, and 3717, respectively.

Heather Walton and David Dainak et. al. 2015 conducted research on the Health Impacts of Air pollution in London which estimated

the mortality burden due to Particulate Matter in 2017 for London. According to the results, 3,537 fatalities at average ages or 52,630 life-years lost are estimated to represent the entire mortality burden of anthropogenic $PM_{2.5}$ for the year 2017. The outcome is comparable to, but slightly greater than, what Public Health England (PHE), using techniques created for national comparisons, predicted for London in 2017. (Gowers et al., 2014). A decrease in concentrations, to which policy interventions will have contributed, as well as some modifications to the prior methods and inputs, such as using anthropogenic rather than total $PM_{2.5}$ and declines in baseline mortality rates, are responsible for part of the decrease in the estimate for $PM_{2.5}$ attributable deaths from the previous estimate (4,267 deaths in 2008 based on concentrations in 2006) (Miller, 2017). As further measures have been taken to minimize emissions, further reductions should take place after 2017. However, depending on how the weather affects concentrations, this may or may not be noticeable in a given year.

Atinder Pal Singh et. al. 2021 conducted research on the Assessment of Health Impacts of $PM_{2.5}$ in Kathmandu Nepal using the WRF-CHEM model. The end result was an analysis and determination of the lung cancer mortality rate in the Kathmandu Valley. The mortality rate (per 100,000 persons)

In the Kathmandu Valley was taken to be 607.8 owing to diseases from all causes (apart from accidents). There will be 19 fatalities from lung cancer and 175 from all causes in December 2019, both of which were caused by $PM_{2.5}$. The findings indicated that the death rate in the area increases as emissions and population density increase.

IV. STUDY AREA

With a total land area of 243,290 square kilometers (93,935 square miles), Uttar Pradesh is the fourth-largest state in India and nearly the same size as the United Kingdom. With a rapid pace of population increase, Uttar Pradesh has a sizable population. Its population increased by more than 26% between 1991 and 2001. India's most populated state, Uttar Pradesh, with 199,581,477 residents as of 1 March 2011. The state is responsible for 16.2% of India's population. One of the densely populated states with the highest densities of population in the nation, with 828 persons per square kilometer.

Table 1 List of cities in the study

City	Latitude(N)	Longitude(E)
Lucknow	26.847	80.9462
Kanpur	26.1197	85.3914
Agra	27.1767	78.0081
Ghaziabad	28.6692	77.4538
Gautam Buddha Nagar	28.3383	77.6078

V. METHODOLOGY

This study attempts to investigate the effects of particulate matter especially $PM_{2.5}$ over the health of the individuals residing in the state of Uttar Pradesh by using AIRQ+ software and finding out the attributable burden of particulates on the health of an individual. The health risk assessment is based on the population attribute fraction (PAF) which is defined as the fraction of health consequences in public exposed to a specific air pollutant. Now it is required to find out the attribute burden of a specific health outcome of specific pollutant over all age groups.

A. Steps involved

Collection of data regarding death parameters from 2017-19 for the state of UTTAR PRADESH from GBD.

1) Calculation of annual average of $PM_{2.5}$ values for the state of Uttar Pradesh from 2017- 19.
2) Finding out the relative risk for exposure to a particulate pollutant.
3) Determining the population Attributable Fraction for the pollutant.
4) Finding out the total burden of a specific health outcome for the pollutant.

VI. DATA COLLECTION

Data regarding the annual average concentration of $PM_{2.5}$ for the various regions in Uttar Pradesh has been collected from Central Pollution Control Board (CPCB), Uttar Pradesh Pollution Control Board (UPPCB), National Air Quality Monitoring Program (NAQMP portal. (https://app.cpcbccr.com/state_CAAQMS/#/dashboard/landing/UPPCB)

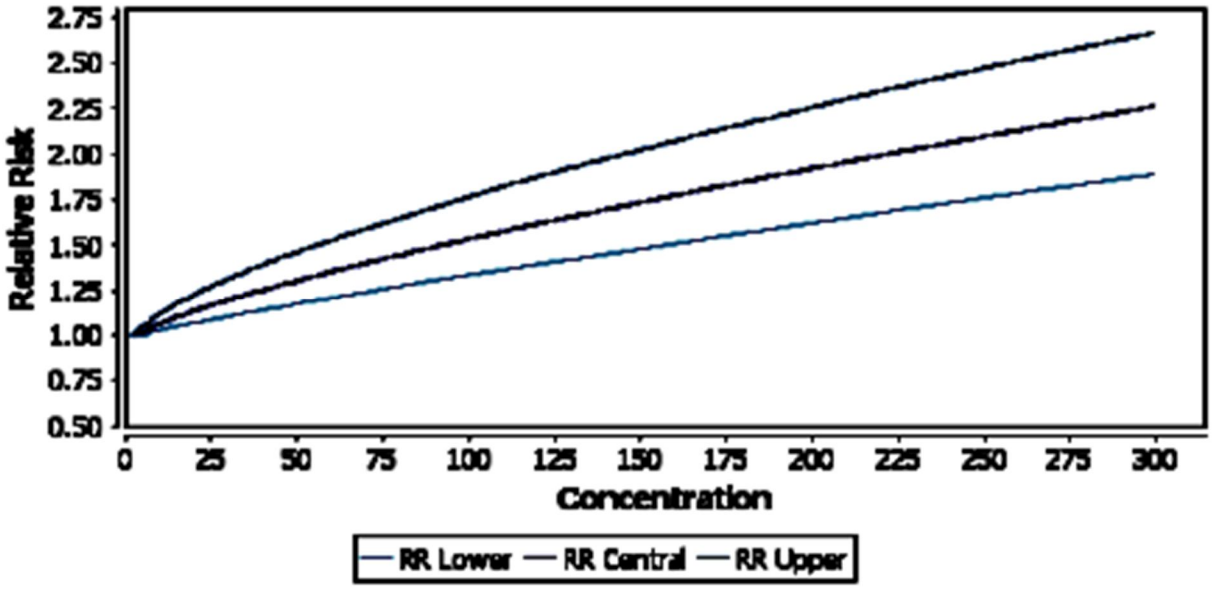
Data regarding population for various districts of Uttar Pradesh has been collected from Census 2011 by Office of Registrar General of India under the Ministry of Home Affairs and from the world population review. (https://censusindia.gov.in/pca/Searchdata.aspx);

Data regarding deaths/Mortality, Disability-Adjusted Life Years, and Years Lived with Disability have been collected from theGlobal Burden of Disease (GBD) portal Under the Institute of Health Metrics and Evaluation (IHME) for the period of 2017-19 for various age groups starting from 25 and above with a class interval of 5 years exclusively. (https://vizhub.healthdata.org/gbd-compare/

VII. RESULT ANALYSIS

A. Lung Cancer

Lung cancer is called Lung carcinoma is basically a malignant lung tumor that is due to uncontrolled growth of tissues in the lungs. The majority of cases of lung cancer are due to smoking. But certain cases are said to occur in nonsmokers also. Nonsmokers are exposed to various forms of air pollution, asbestos particles, and passive smoking.



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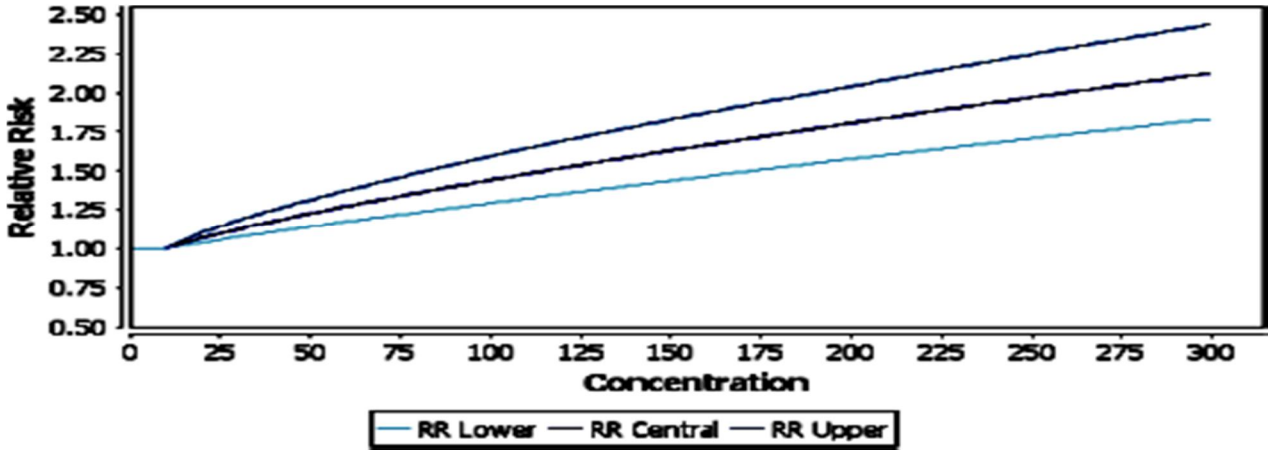

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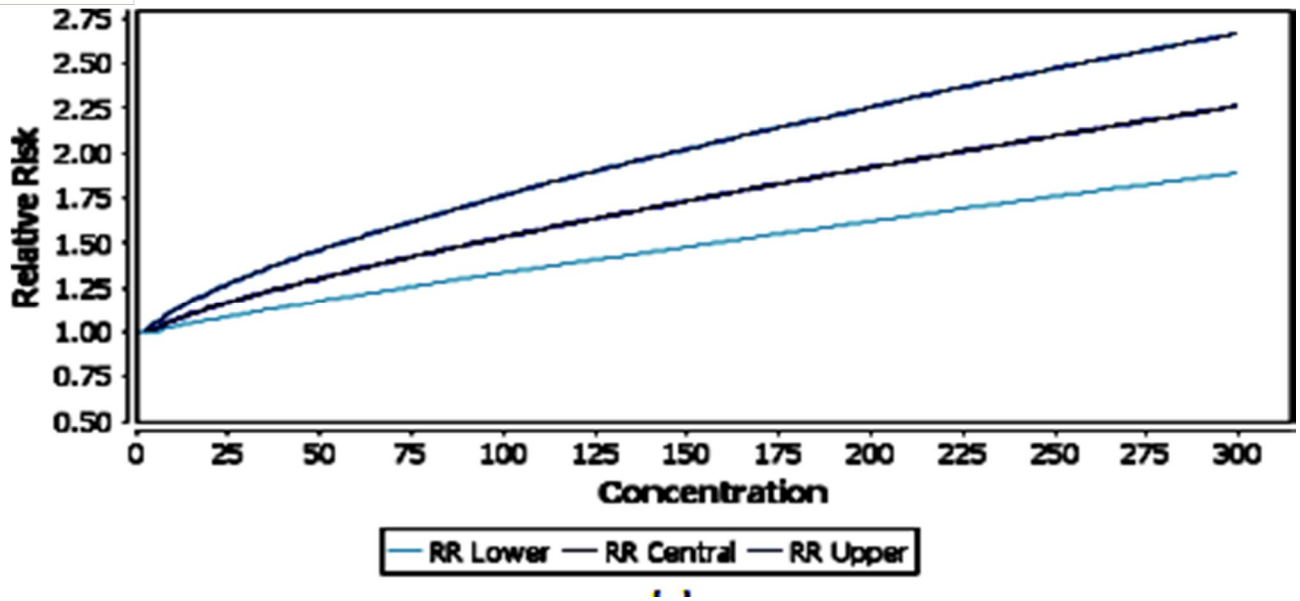

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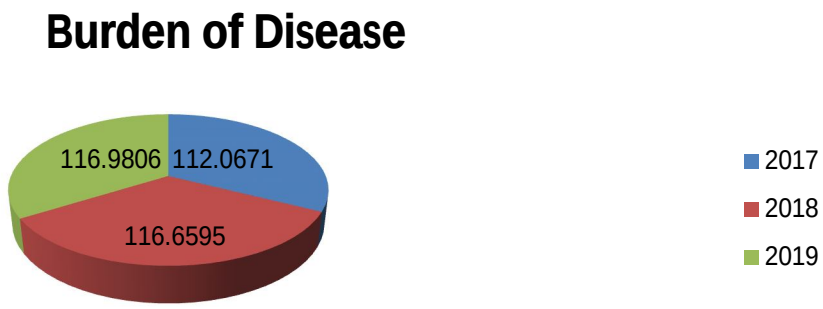
Fig 2 Plot of Relative Risk Vs Concentration for Lung Cancer for the year (a) 2017, (b) 2018 and (c)2019 respectively.

The Burden of Disease (per 1,000,000 population) for Lung Cancer for the year as per the GBD portal is 112.067, 116.659 and 116.981 for the years 2017, 2018, and 2019 respectively.
The values of relative risk (central) for Lung Cancer for the year 2017, 2018, and 2019 is 1.575,
1.565 and 1.470 respectively.
The Population Attributable Fraction for the Lung Cancer for the Year 2017, 2018, and 2019 is 0.365, 0.361, and 0.319 respectively.
The attributable burden for the disease for the year 2017, 2018 and 2019 is 38423, 41677 and 45153 respectively which is which is 8.46% increase and 8.34% increase respectively in comparison to previous years.

Table 2

Year	Burden of Disease (Mortality per 1 lakh)	Relative Risk	Population Attributable Fraction	Attributable Burden
2017	112.0671	1.575	0.365	38423
2018	116.6595	1.565	0.361	41677
2019	116.9806	1.470	0.319	45153



Chronic Obstructive Pulmonary Disease

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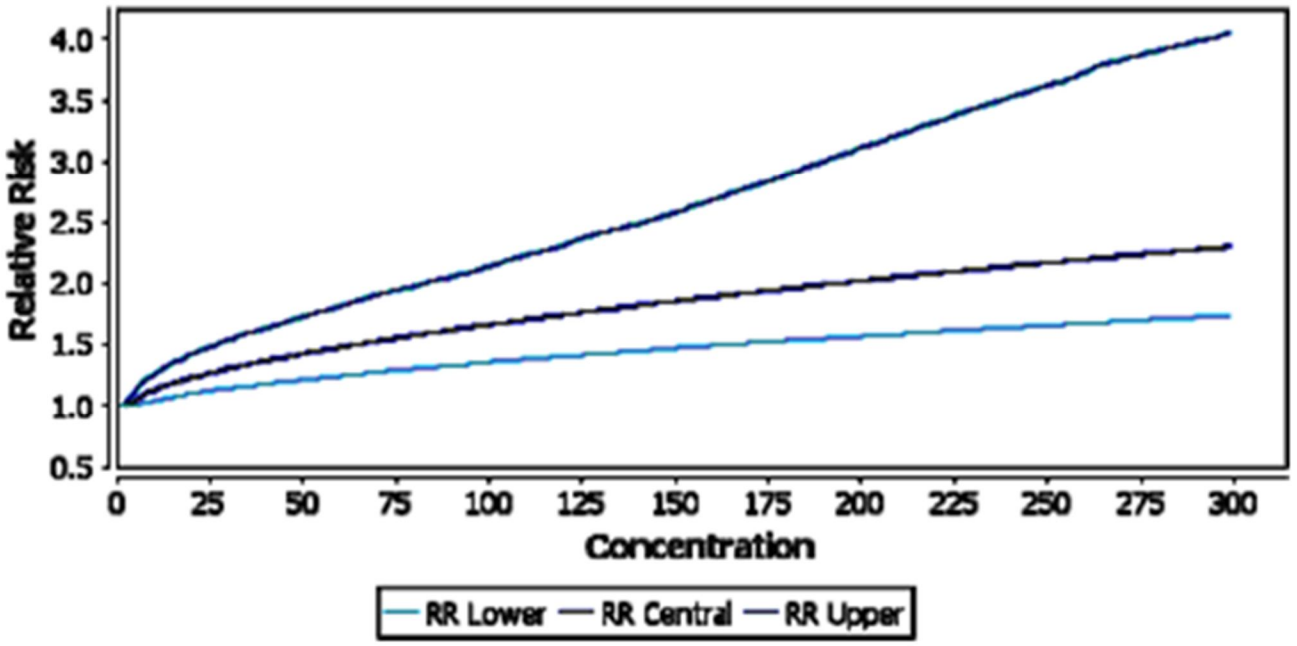
COPD is defined as a long-term progressive Lung-disease having long term respiratory symptoms and limited air flow through the body. The condition of the affected destroys with everyday activities. This disease is incurable. It is basically caused due to indoor and outdoor pollution such as use of coking coal, biomass as fuel, wood and dry dung for cooking activities. By the various measures taken by the Government of India one such being UJJWALA Yojana indoor pollution has been controlled to some extent. The relative risk for the COPD is 1.705, 1.696 and 1.601 for the year 2017, 2018 and 2019 respectively



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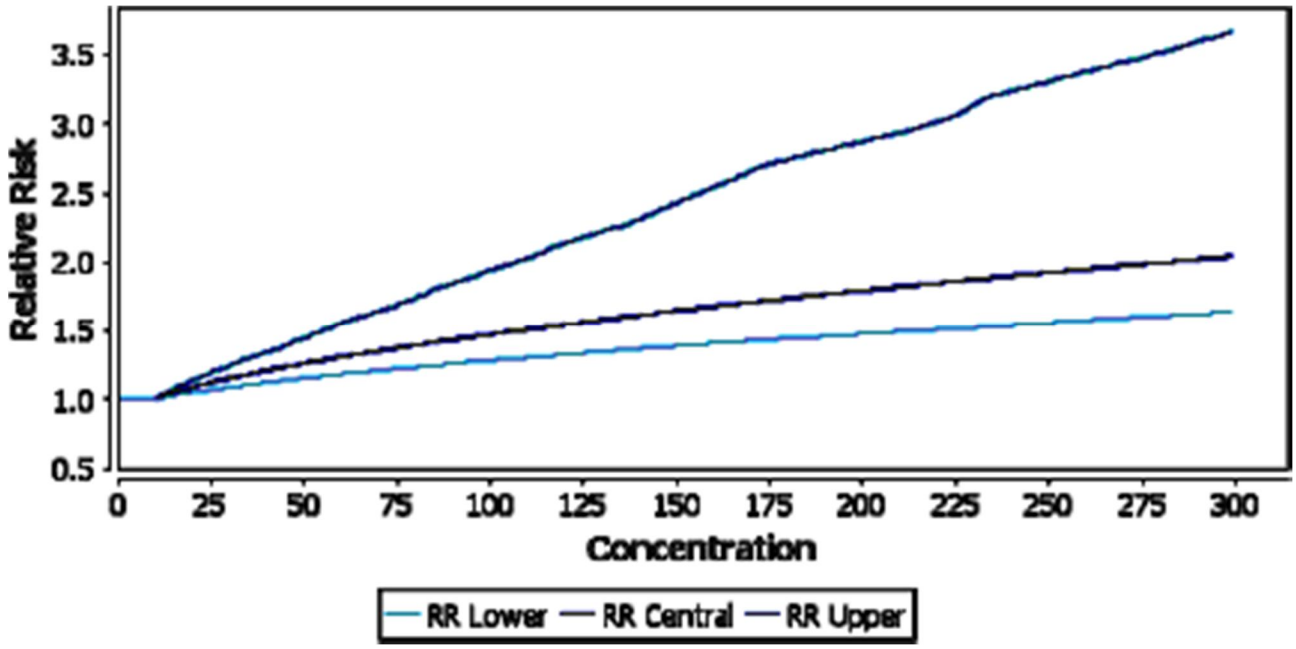

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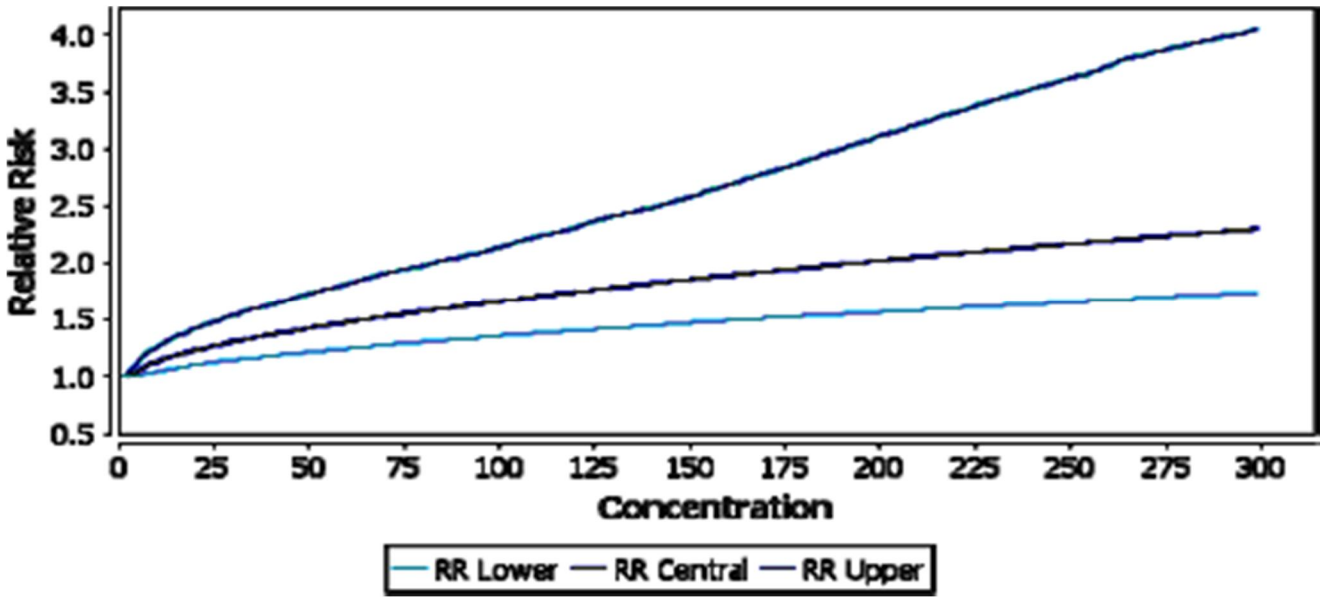

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Fig 3- Plot showing variation of Relative Risk with Concentration for the Year (a)2017 (b) 2018and (c) 2019 respectively for COPD

The Burden of Disease (per 1,000,000 population) for COPD for the year as per the GBD portal is 7542.276, 5592.558, and 5453.056 for the years 2017, 2018, and 2019 respectively.

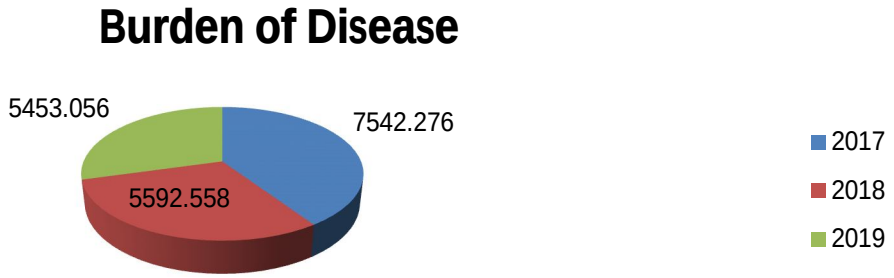
The values of relative risk (central) for Lung Cancer for the year 2017, 2018, and 2019 is 1.705, 1.696, and 1.601 respectively.

The Population Attributable Fraction for the Lung Cancer for the Year 2017, 2018, and 2019 is 0.413, 0.410, and 0.375 respectively.

The attributable burden due to COPD is 2269377, 2476899, and 2728883 for the years 2017, 2018, and 2019 respectively which is an increase of 9.14% and 10.17% respectively.

Table 3

Year	Burden of Disease (Mortality per 1 lakh)	Relative Risk	Population Attributable Fraction	Attributable Burden
2017	7542.276	1.705	0.413	2269377
2018	5592.558	1.696	0.41	2476899
2019	5453.056	1.601	0.375	2728883



VIII. CONCLUSION

The present study has evaluated the trend and health effects of $PM_{2.5}$ in the state of Uttar Pradesh.

1) Although the Government of India is implementing several monitoring programs and mitigation measures, the PM concentration in most of the study areas is found to exceed stipulated NAAQS and WHO standards.

2) The common mitigation measures for all the cities will result in poor outcomes.

3) Thus city-specific measures can be effective in implementing and reducing PM concentration. Air Q+ software is utilized to quantify long-term and short-term health effects.

4) It can be concluded that irrespective of the health endpoints, the cities with high PM concentration and exposed populations can lead to maximum hospital admissions and mortality.

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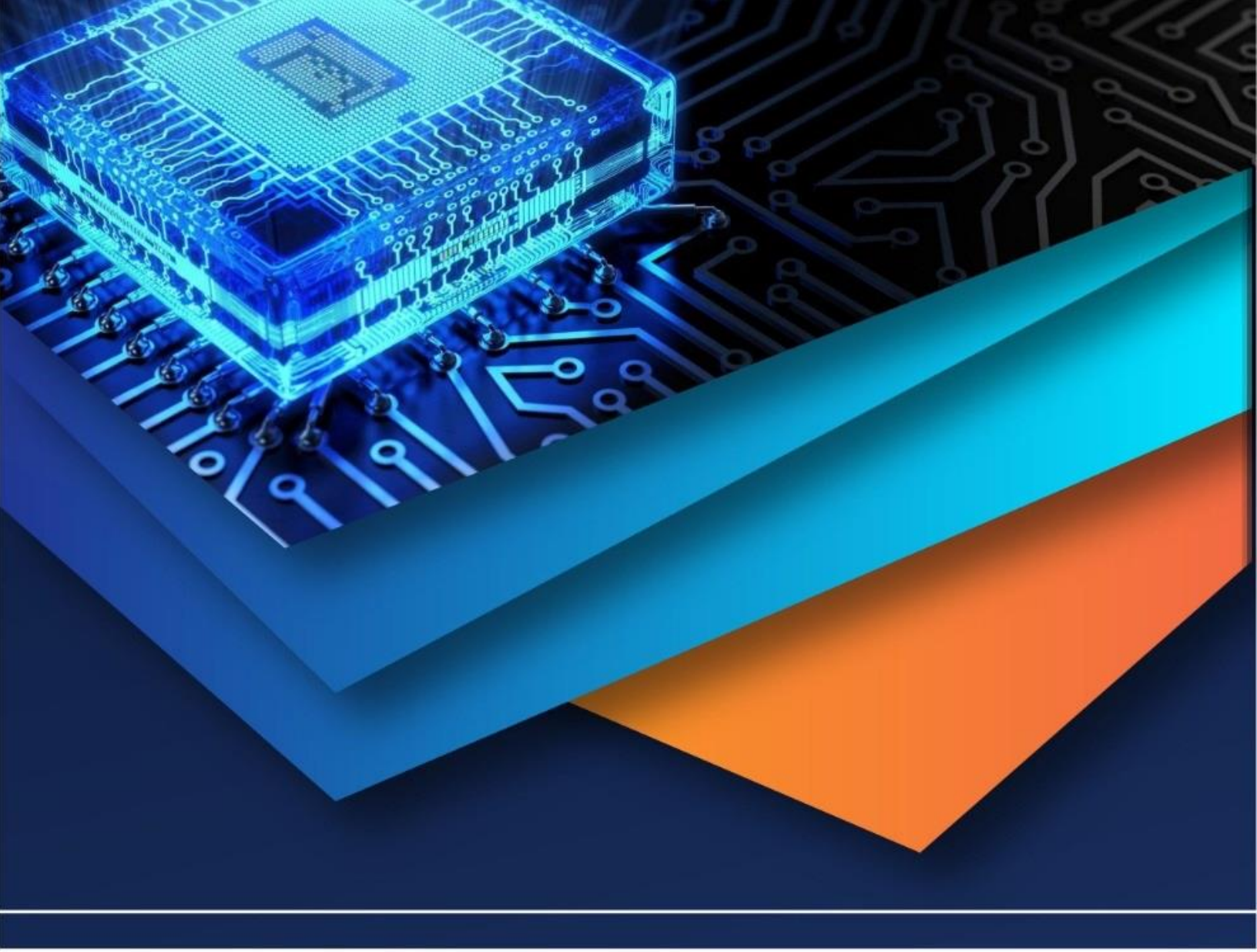

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