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Assessment of attributable proportion and relative risk of air pollutants to different morbidities in Srirangam Zone of Tiruchirappalli City, Tamil Nadu

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Abstract

This study assesses the health impacts of air pollutants, specifically PM_{10}, $PM_{2.5}$, CO, and NO_2, on various morbidities in Srirangam zone of Tiruchirappalli City using AirQ+ model. The air quality collected using the Aeroqual AQM 65. Air quality data were analysed to estimate the attributable proportion of pollutants to respiratory and cardiovascular conditions, including Chronic Obstructive Pulmonary Disease (COPD), Ischemic Heart Disease (IHD), Myocardial Infarction (MI), and hospital admissions due to respiratory diseases. Results showed that $PM_{2.5}$ and NO_2 are significantly associated with increased risks for both respiratory and cardiovascular morbidities. $PM_{2.5}$ concentrations contributed to a 5.25% attributable proportion for COPD and 19.4% for IHD, while NO_2 levels were linked to a 2.45% attributable proportion for respiratory hospital admissions. In contrast, PM_{10} and CO levels showed minimal health impact. The findings emphasize the need for continued air quality monitoring and targeted interventions to reduce pollutant levels and mitigate adverse health effects in the study area.

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Introduction

Air pollution has become one of the biggest health problems today, especially in cities where fast industrial growth, traffic emissions, and crowded populations have made pollution worse.

Breathing in harmful pollutants like particulate matter (PM10 and PM2.5) and nitrogen dioxide (NO_2) is known to cause various health issues, including lung and heart diseases, more frequent hospital visits, and early deaths. The World Health Organization (WHO) reports that air pollution causes millions of deaths each year, with people living in cities being most at risk due to pollution from vehicles, factories, and construction. Srirangam is an area that combines residential neighbourhoods, commercial zones, and religious sites. As the city expands, the demand for transportation and infrastructure increases, making pollution worse. This poses a significant health risk, particularly for vulnerable population. It is crucial to assess the health risks associated with exposure to key pollutants, including PM_{10}, $PM_{2.5}$, and NO_2. These pollutants are known to penetrate deep into the lungs and bloodstream, leading to inflammation, respiratory problems, and even contributing to chronic conditions like asthma and heart disease. Understanding the attributable risk of these pollutants to specific morbidities is essential for developing effective public health interventions, Pope and Dockery (2006). This study aims to evaluate the attributable risk of air pollutant such as PM_{10}, $PM_{2.5}$, and NO_2 on morbidity in Srirangam, with a focus on identifying the extent to which these pollutants contribute to health outcomes. The study gives important information about how air pollution affects public health in the area and helps guide specific actions to reduce its impact. The particulate matter is released from sources like vehicle exhaust, industrial emissions, construction sites, and dust. $PM_{2.5}$ is particularly harmful because it can penetrate deep into the lungs. Nitrogen Dioxide (NO_2) is a gas from burning fossil fuels in cars, factories, etc. High levels can irritate the lungs and increase the risk of respiratory problems. This study is essential for protecting public health.

Materials and methods

Study area

Srirangam is an island town situated in the Tiruchirappalli district of Tamil Nadu, India. Geographically, it lies between the Kaveri River and its tributary, the Kollidam River. The town is an integral part of the larger Tiruchirappalli city; Srirangam is not only a religious hub but also a growing urban area, experiencing increasing pressures from urbanization and infrastructure development. Also it is one of the main Pilgrim Centres in the country.

Climatology

Srirangam has a tropical climate with three main seasons: summer, monsoon, and winter. Summers are hot and dry, with temperatures often exceeding 40°C. The monsoon season brings moderate rainfall, primarily from the southwest monsoon, providing some relief from the heat. Winters are mild, with average temperatures ranging from 20°C to 25°C. The hot and dry conditions, particularly in summer, can worsen air quality by increasing the accumulation of dust and particulate matter.

Air quality monitoring

Air samples, including carbon monoxide (CO), nitrogen dioxide (NO2), and particulate matter ($PM_{2.5}$ and PM_{10}), were collected in Srirangam using Aeroqual AQM 65 equipment during January to March 2024. The AQM 65 provides real-time measurements with high accuracy. The average values for the respective pollutants were calculated using MS-Excel, allowing for further analysis of air quality trends and the potential impact on public health in the region.

Health data

Health data related to respiratory and cardiovascular diseases such as Chronic Obstructive Pulmonary Disease (COPD), ischemic heart disease (IHD), coronary artery disease (CAD), and Myocardial Infarction (MI) and Hospital admissions was collected at the Government Hospital in Srirangam, Trichy City for the period of January to March 2024.

AirQ+ prediction model

The AirQ+ model is developed by the World Health Organization (WHO). It is used to estimate the health impacts of air pollution in Srirangam. The model integrates air quality data, particularly the concentrations of pollutants like carbon monoxide (CO), nitrogen dioxide (NO_2), $PM_{2.5}$, and PM_{10}, with local health data to quantify the potential risks and outcomes associated with exposure to these pollutants. The AirQ+ model uses epidemiological data to estimate the number of cases of mortality and morbidity that can be attributed to specific pollutants in each population (WHO, 2024).

Results

The air quality data for the area indicates that carbon monoxide (CO) levels, measured at 1.98 ppm, are within safe limits and do not pose significant health risks. Nitrogen dioxide (NO_2) concentration stands at 90.35 µg/m³, which exceeds the recommended annual exposure limits but remains within acceptable limits for short-term exposure. Particulate matter levels are also relatively low, with $PM_{2.5}$ at 5.94 µg/m³ and PM_{10} at 7.26 µg/m³, both of which are considered safe for short-term exposure. Overall, while CO and particulate matter levels are within safe ranges. The results are depicted in Table 1.

Table 1. Average concentrations of air pollutants in Srirangam during Jan-March 2024

Month	CO (ppm)	NO_2 (µg/m³)	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)
January	2.10	104.44	5.98	7.5
February	2.69	64.88	6.36	8.79
March	1.14	101.72	5.47	6.6
Average	1.98	90.35	5.94	7.26

The air quality data, analysed using the AirQ+ model, provides valuable insights into the potential health impacts of the measured pollutants.

Particulate matter ($PM_{2.5}$)

With an average concentration of 5.94 µg/m³, $PM_{2.5}$ is associated with a 5.25% attributable proportion for chronic obstructive pulmonary disease (COPD). This indicates a moderate impact on respiratory health, with a relative risk of 1.01 suggesting a slight increase in risk. For ischemic heart disease (IHD), the attributable proportion is higher at 19.4%, reflecting a more significant association with elevated $PM_{2.5}$ levels. The relative risk of 1.05 suggests a moderate increase in risk for cardiovascular conditions. The results represented in Table 2 and Fig. 1 and 2.

Table 2. Attributable proportion and relative risks of air pollutants

Pollutant	Concentration of air pollutants	Heath concern	Attributable proportion (%)	Relative risk
$PM_{2.5}$ (µg/m³)	5.94	COPD	5.25	1.01
$PM_{2.5}$ (µg/m³)	5.94	IHD	19.4	1.05
NO_2(µg/m³)	90.35	Hospital admissions related respiratory diseases	2.45	1.12
CO(ppm)	1.98	Mortality respiratory diseases	0	0
PM_{10}(µg/m³)	7.26	Myocardial infarction (MI)	0	0

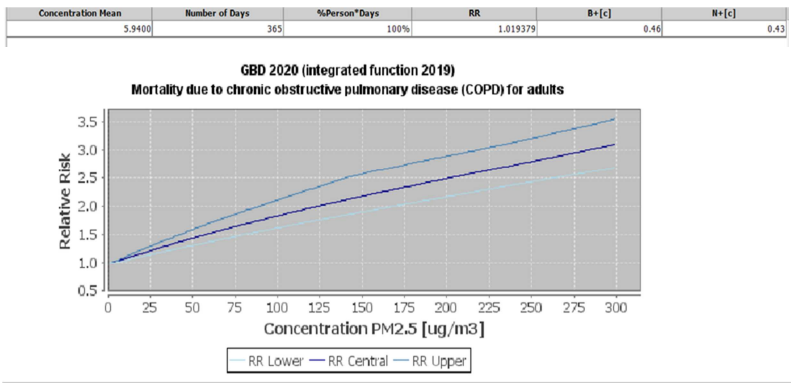

Fig. 1. Relative risk of PM2.5 in COPD

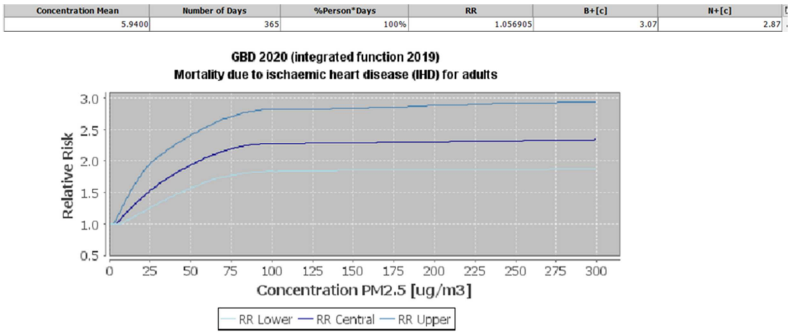

Fig. 2. Relative risk of PM2.5 of IHD

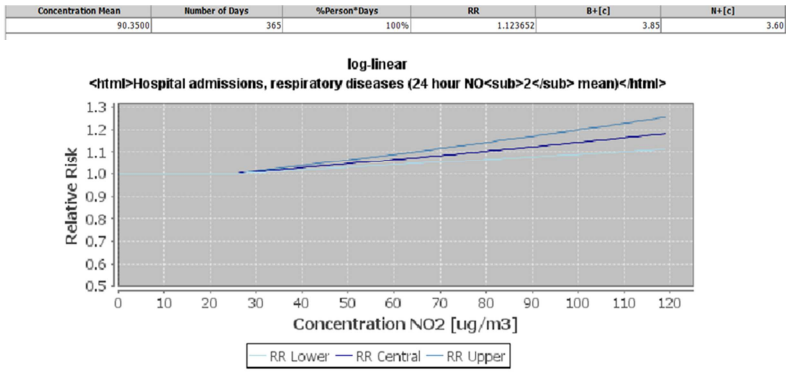

Fig. 3. Relative risk of NO_2 in Hospital admissions related respiratory diseases

Nitrogen dioxides (NO_2)

The average NO_2 concentration of 90.35 µg/m³ is linked to a 2.45% attributable proportion for hospital admissions related to respiratory diseases. The relative risk of 1.12 indicates a moderate increase in risk for respiratory conditions associated with higher NO_2 levels. The results are represented in Table 2 and Fig. 3.

Carbon monoxide (CO)

At an average concentration of 1.98 ppm, CO does not show any attributable proportion for mortality related to respiratory diseases, with a relative risk of 0. This suggests that CO levels at this concentration are not significantly associated with increased mortality risk from respiratory conditions. The results are depicted in Table 2.

Particulate matter (PM_{10})

The concentration of PM_{10} is 7.26 µg/m³. There is no significant attributable proportion or relative risk calculated for myocardial infarction (MI) at this level, indicating that PM_{10} at this concentration does not have a substantial impact on MI risk in this context. The results are indicated in Table 2.

Overall, the results underscore the notable health impacts of $PM_{2.5}$ and NO_2, particularly concerning respiratory and cardiovascular health. While CO and PM_{10} levels are lower and do not show significant health risks at the concentrations measured, continuous monitoring and management of air quality are essential to mitigate health impacts and protect public health.

Discussion

The air quality data for the area indicates that the levels of carbon monoxide (CO), measured at 1.98 ppm, are within permissible limit of NAAQS prescribed by CPCB and do not present significant health risks. Similarly, the particulate matter levels are relatively low, with $PM_{2.5}$ at 5.94 µg/m³ and PM_{10} at 7.26 µg/m³. However, the concentration of nitrogen dioxide (NO_2) at 90.35 µg/m³ exceeds the recommended annual exposure limits but remains acceptable for short-term exposure. Despite this, the elevated NO_2 levels warrant closer monitoring

due to their potential health impacts. The analysis conducted using the AirQ+ model highlights several key health implications related to air pollutants. $PM_{2.5}$, with an average concentration of 5.94 µg/m³, shows a moderate impact on respiratory health, contributing to a 5.25% attributable proportion for chronic obstructive pulmonary disease (COPD), and a significant association with ischemic heart disease (IHD), with an attributable proportion of 19.4%. Brook *et al.* (2010) and Hoek *et al.* (2013) showed long tern effects of health impacts.

NO_2, at an average concentration of 90.35 µg/m³, presents a 2.45% attributable proportion for respiratory hospital admissions, with a relative risk of 1.12. Carbon monoxide (CO) levels at 1.98 ppm do not show an attributable proportion for respiratory mortality, suggesting minimal health risk. PM_{10} concentrations at 7.26 µg/m³ also show minimal impact on myocardial infarction (MI). Overall, the data underscores the health risks posed by elevated levels of $PM_{2.5}$ and NO_2, emphasizing the need for continued monitoring and targeted interventions to reduce exposure, while CO and PM_{10} appear to pose less immediate concern at current levels. The similar results are discussed in urban areas by Beelen *et al.* (2008). The minimal health risks associated with current CO and PM_{10} concentrations reflect their comparatively lower levels, though continued monitoring is essential to prevent future exceedances. Overall, these results highlight the importance of air quality management strategies focused on reducing $PM_{2.5}$ and NO_2 to mitigate the long-term health effects on urban populations.

Conclusion

The findings of this study underscore the significant health impacts of $PM_{2.5}$ and NO_2 on respiratory and cardiovascular morbidities in Srirangam, while PM_{10} and CO were found to have minimal health effects at current levels. $PM_{2.5}$ was particularly associated with elevated risks for Chronic Obstructive Pulmonary Disease (COPD) and Ischemic Heart Disease (IHD), while NO_2 showed a notable contribution to hospital admissions for respiratory conditions. These results highlight the urgent need for targeted air quality management strategies to reduce $PM_{2.5}$ and NO_2 concentrations, which are key contributors to adverse health outcomes in the region. Continued surveillance and implementation of mitigation measures will be crucial for protecting public health and reducing the burden of air pollution-related diseases.

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