# ASSOCIATION BETWEEN AIR POLLUTION AND UPPER RESPIRATORY DISEASES IN HAI PHONG

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*This study investigated the association between air pollution levels and the incidence of upper respiratory tract infections (URTIs) in Hai Phong City, 2017 - 2021, and proposes a sustainable framework for community health education. A cross-sectional descriptive study was conducted. From 2017 - 2019, concentrations of $SO_2$, $NO_2$, and suspended particulate matter exceeded permissible thresholds. A strong positive correlation was found between these pollutants and the incidence of pharyngitis, nasopharyngitis, rhinitis, sinusitis, laryngitis, and adeno-tonsillitis. In contrast, carbon monoxide (CO) showed no statistically significant association with any disease category. The findings underscore air pollution as a major risk factor for URTIs in Hai Phong City. Sustainable community health interventions-including public communication of air quality indices, promotion of personal protective practices, and upstream pollution mitigation - are vital for improving respiratory health outcomes.*

**Keywords: Air pollution, upper respiratory tract infections, community health education.**

## I. INTRODUCTION

Air pollution is one of the most pressing environmental challenges globally. According to the World Health Organization (WHO) 2022 report, approximately 99% of the global population lives in areas where fine particulate matter (PM2.5) concentrations exceed recommended safety thresholds, contributing to an estimated 7 million deaths annually. These deaths are primarily due to cardiovascular diseases, stroke, lung cancer, asthma, and chronic obstructive pulmonary disease (COPD).[1-3]

In Vietnam, air pollution has emerged as a significant public health concern. In 2022, PM2.5 levels in Hanoi exceeded WHO guidelines by over 3.12 times, placing the country among those with the poorest air quality in Southeast Asia.[4] Numerous studies, both domestic and international, have identified a strong association between elevated levels of pollutants - such as PM2.5, $NO_2$, ozone, $SO_2$, and CO - and increased incidence of respiratory diseases, especially among vulnerable populations like children, the elderly, and individuals with pre-existing conditions. Notably, in 2016, air pollution was estimated to be responsible for over 60,000 deaths in Vietnam.[5]

Hai Phong city, as one of Vietnam's largest industrial port cities, has witnessed frequent episodes of air pollution due to its dense traffic, industrial activities, and rapid urbanization.[6] From 2017 to 2021, air quality in the city often deteriorated beyond permissible levels. In 2019, Hai Phong recorded a PM2.5 - attributable death rate of 81.9 per 100,000 people.[7] However, comprehensive investigations into the specific health impacts of air pollution in Hai Phong -

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particularly regarding upper respiratory tract infections (URTIs) and corresponding public health responses - remain scarce.

This study aimed to examine the relationship between air pollution and URTI incidence in Hai Phong over a five-year period (from 2017 to 2021) and to propose sustainable, community-cantered health education interventions as part of a long-term response to environmental health risks.

## II. MATERIALS AND METHODS

### 1. Subjects

***Environmental monitoring indicators***

Environmental data were collected from air quality monitoring stations in Hai Phong City, including concentrations of sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), and suspended particulate matter (PM).

***Patient records***

The study included patients diagnosed with upper respiratory tract infections (URTIs) per ICD-10 codes: rhinitis (J30), pharyngitis (J02), sinusitis (J01), otitis media (H66), laryngitis (J04), nasopharyngitis (J00), and adeno-tonsillitis (J35).[8]

***Inclusion criteria***

Patients diagnosed with URTIs according to hospital reporting list between 2017 and 2021.

### 2. Methods

A Cross-sectional descriptive study was conducted at hospitals and residential areas near major pollution sources in Hai Phong from June 2024 to June 2025.

***Data Collection***

*Environmental data*

Field surveys were conducted at selected sites. Air samples were collected following regulatory protocols on sample preservation and environmental monitoring standards issued under Vietnam's QCVN regulations (QCVN 05:2013/BTNMT) 111.[9]

*Medical data*

Medical records of URTI patients were retrieved from ENT outpatient and inpatient departments at Hai Phong International General Hospital from 2017 - 2021.

***Data Processing and Analysis***

Environmental and health data were digitized, cleaned, and checked for consistency. All statistical analyses were performed using STATA version 16.0. Descriptive statistics, Pearson's correlation, and temporal ecological correlation analysiswere applied to examine the association between pollutant levels and URTI incidence.

***Study Variables***

Environmental (quantitative): $SO_2$ (µg/m³), $NO_2$ (µg/m³), PM (µg/m³), CO (mg/m³). Health outcomes (quantitative): number of URTI cases (total and by diagnosis). Demographic (optional): age group, gender (if applicable from medical records). Time (Ordinal/Discrete): year of record (2017 - 2021)

### 3. Research ethics

The study protocol was approved by relevant hospital boards. All data were anonymized and handled in accordance with ethical standards, ensuring privacy, integrity, and scientific transparency.

## III. RESULTS

A total of 93,943 patients were included in the study sample, with a slight predominance of females (56.1%) compared to males (43.9%). The mean age was 37.6 years old (SD = 17.47), ranging from 0 to 101 years old. This demographic distribution reflects a broad representation across age groups and both genders, supporting the generalizability of the study's findings on upper respiratory tract infections in Hai Phong.

**Table 1. General Characteristics of the Study Sample (n = 93,943)**

| Characteristics | Quantity (n) | Percentage (%) |
|---|---|---|
| *Gender* | | |
| Male | 41,278 | 43.9 |
| Female | 52,665 | 56.1 |
| | **Mean ± SD** | **Min - Max** |
| Age | 37.6 ± 17.47 | 0 - 101 |

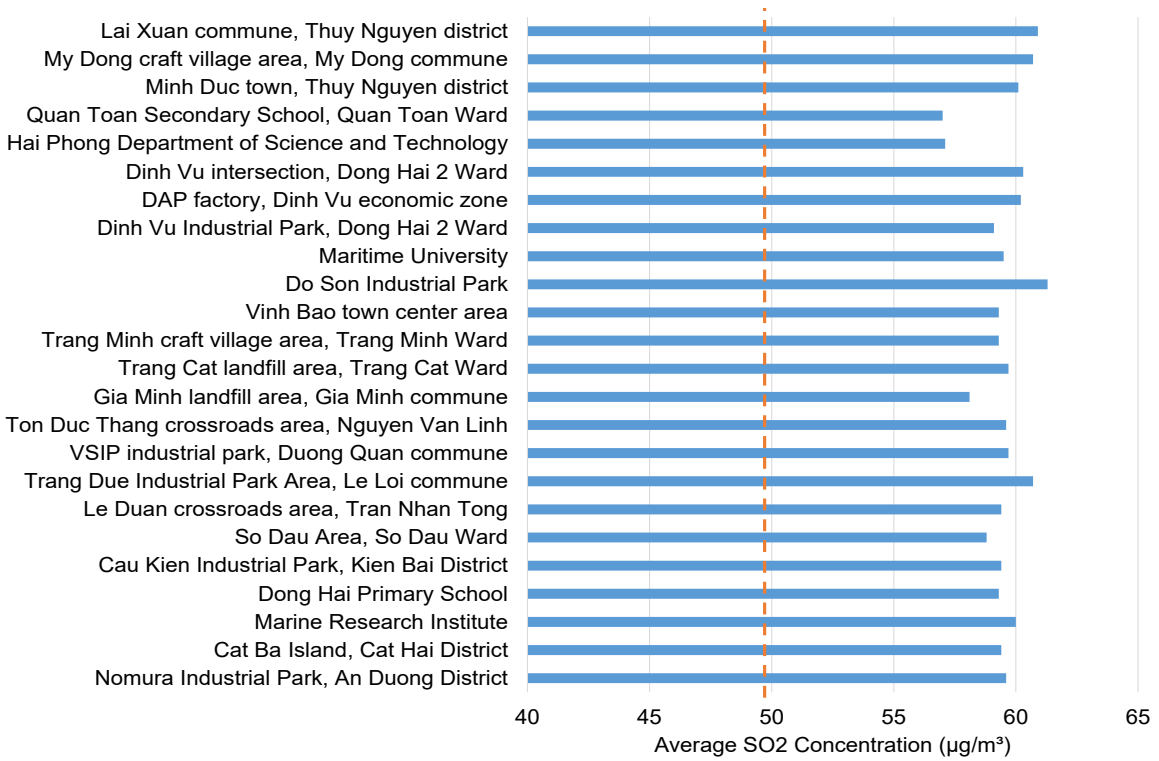


**Chart 1. Average $SO_2$ Concentration in Densely Populated Areas of Hai Phong (2017 - 2021)**

Chart 1 chart illustrates the average concentrations of sulfur dioxide ($SO_2$) recorded in densely populated areas of Hai Phong between 2017 and 2021. All monitoring sites exceeded the QCVN 05:2013/BTNMT annual limit of 50 µg/m³. The highest levels were observed in Do Son Industrial Zone (61.3 µg/m³), Lai Xuan commune (60.8 µg/m³), and several urban-industrial clusters. These findings indicate a widespread elevation in $SO_2$ exposure, particularly in areas near industrial activities and ports.

Chart 2 illustrates the average carbon monoxide (CO) concentrations measured in key residential and industrial areas across Hai Phong from 2017 to 2021. The data show relatively consistent CO levels among locations, ranging from approximately 5,552 to 6,247 µg/m³. The highest concentration was observed at Du An Cang Bien (6,247 µg/m³), while the lowest was recorded at the Department of Science and Technology (5,552 µg/m³).

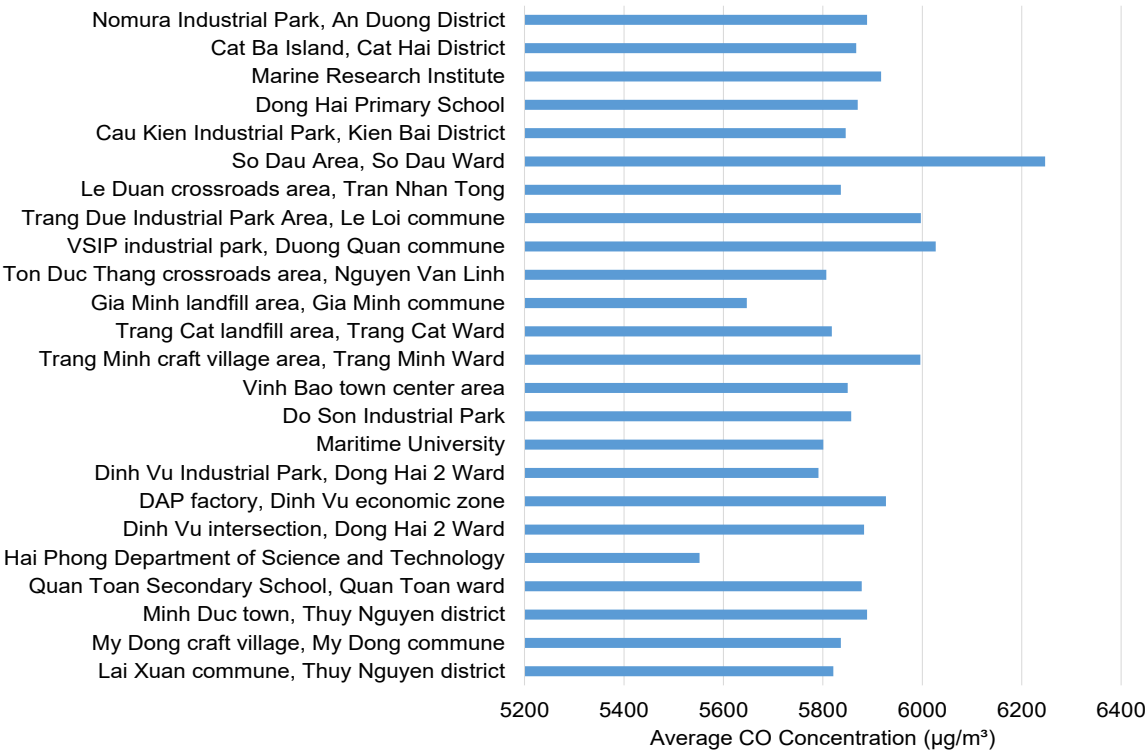


**Chart 2. Average Carbon Monoxide (CO) Concentration in Densely Populated and Industrial Areas of Hai Phong (2017 - 2021)**

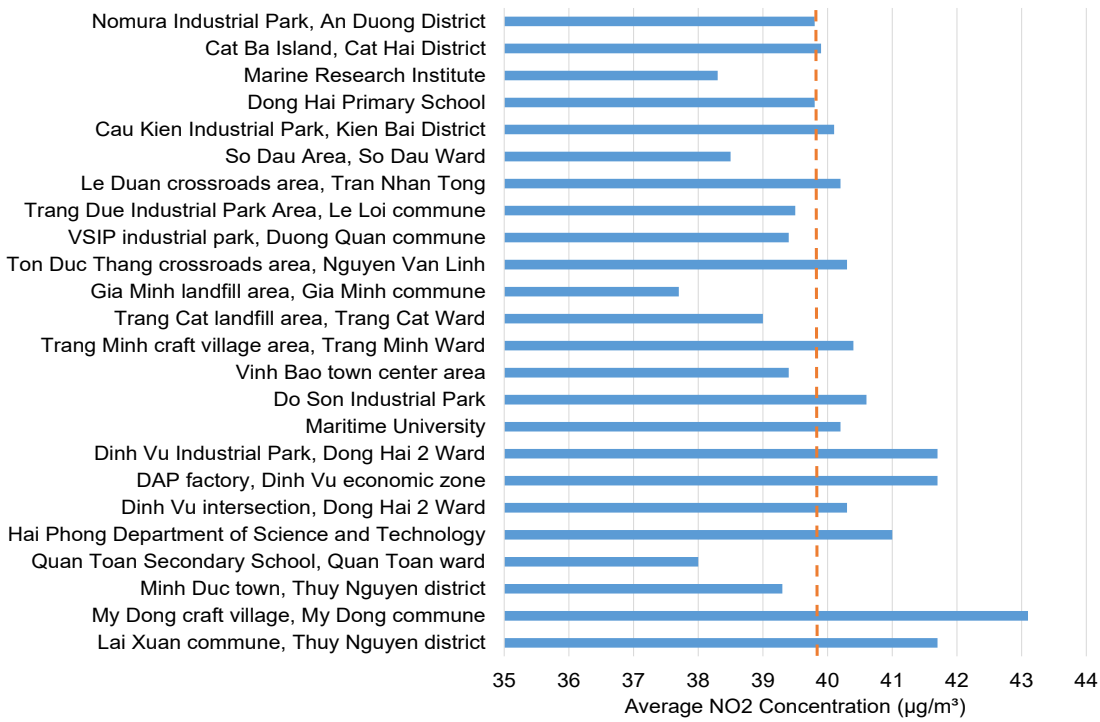


**Chart 3. Average Nitrogen Dioxide ($NO_2$) Concentration in Densely Populated and Industrial Areas of Hai Phong (2017 - 2021)**

Chart 3 presents the average nitrogen dioxide ($NO_2$) concentrations across key residential and industrial zones in Hai Phong between 2017 and 2021. The measured values range from 37.7 µg/m³ to 43.1 µg/m³, with the highest levels recorded in Lang Nghe My Dong (43.1 µg/m³) and Lai Xuan commune (41.7 µg/m³).

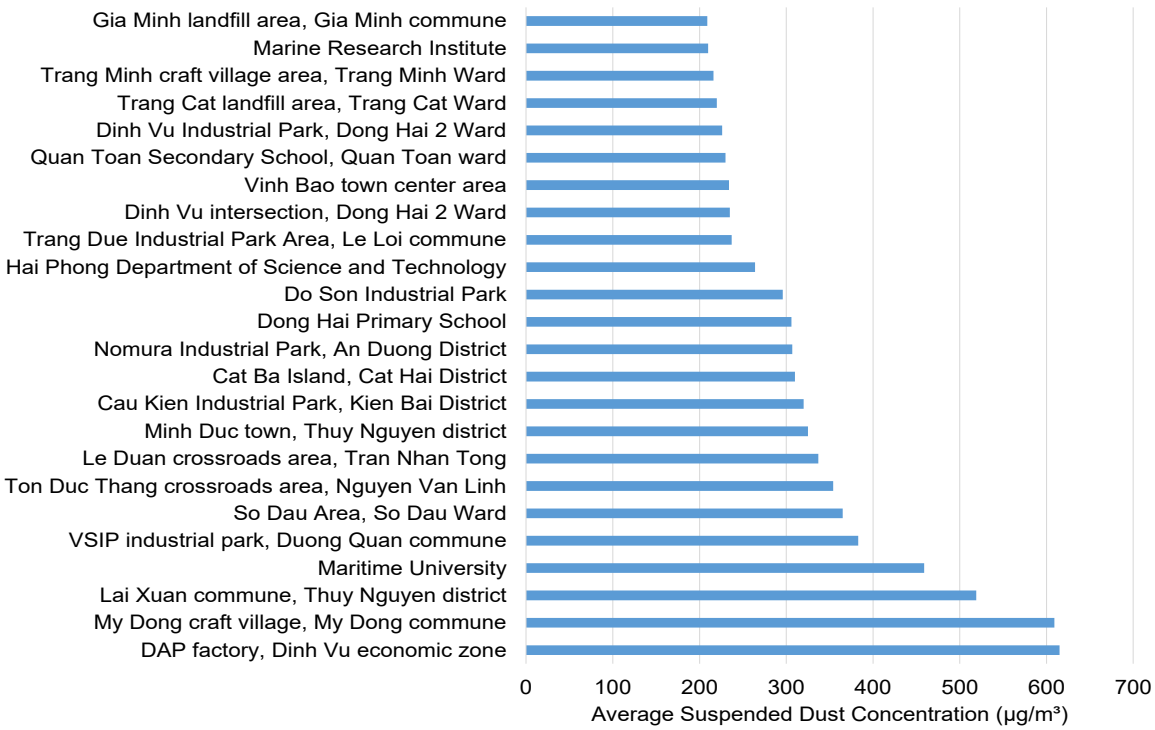


**Chart 4. Average Suspended Dust Concentration in Densely Populated and Industrial Areas of Hai Phong (2017 - 2021)**

Chart 4 illustrates the average concentrations of suspended particulate matter (TSP - total suspended particles) measured across high-density residential and industrial areas in Hai Phong during the period 2017 - 2021. The data reveal considerable variation among locations, ranging from 209 µg/m³ to 615 µg/m³.

The highest TSP levels were observed at Hai Phong University (615 µg/m³), Minh Duc Town (609 µg/m³), and Lang Nghe My Dong (519 µg/m³) - areas associated with construction, heavy traffic, and craft village activities. In contrast, the lowest levels were recorded in VSIP Industrial Zone (209 µg/m³) and Rac Gia Minh area (216 µg/m³).

**Table 2. Average Annual Pollutant Concentrations (µg/m³)**

| Pollutant | 2017 | 2018 | 2019 | 2020 | 2021 | QCVN Limit |
|---|---|---|---|---|---|---|
| Sulfur dioxide ($SO_2$) | 352.7 | 355.0 | 359.1 | 159.2 | 161.4 | 350 |
| Carbon monoxide (CO) | 5189 | 5570 | 5981 | 5943 | 5563 | 30,000 |
| Nitrogen dioxide ($NO_2$) | 236.4 | 237.0 | 242.5 | 139.5 | 143.3 | 200 |
| Total suspended particulate (TSP) | 342.0 | 368.0 | 398.0 | 308.0 | 301.0 | 300 |

The average concentrations of $SO_2$ and $NO_2$ exceeded the QCVN 05:2013/BTNMT limits during the years 2017 - 2019, while CO levels remained consistently within acceptable ranges. Suspended particulate matter (TSP) levels surpassed the national threshold in all five years, indicating a persistent concern regarding dust-related air pollution in Hai Phong.

**Table 3. Number of Diagnosed Cases of Acute Upper Respiratory Tract Infections**

| Diagnosis | 2017 | 2018 | 2019 | 2020 | 2021 | Total |
|---|---|---|---|---|---|---|
| Sinusitis | 5,266 | 6,350 | 8,419 | 1,039 | 611 | 21,685 |
| Adenoiditis | 7,852 | 8,148 | 9,910 | 923 | 262 | 27,095 |
| Otitis media | 1,171 | 1,984 | 2,827 | 290 | 197 | 6,469 |
| Rhinitis | 6,436 | 7,628 | 9,940 | 388 | 160 | 24,552 |
| Rhinopharyngitis | 6,516 | 7,326 | 9,493 | 224 | 180 | 23,739 |
| Pharyngitis | 21,133 | 21,798 | 22,568 | 215 | 292 | 66,006 |
| Laryngitis | 1,590 | 2,516 | 4,712 | 576 | 574 | 9,968 |

The number of URTI cases - including pharyngitis, adenoiditis, and rhinitis - peaked during the high-pollution years (2017 - 2019) and declined significantly in 2020-2021. This pattern may reflect both the impact of improved air quality during the pandemic period and changes in healthcare utilization behavior.

**Table 4. Correlation Between Air Pollutants and Acute Upper Respiratory Tract Infections (n = 5 years)**

| Diagnosis | $SO_2$ | | CO | | $NO_2$ | | Suspended Dust | |
|---|---|---|---|---|---|---|---|---|
| | r | p | r | p | r | p | r | p |
| Sinusitis | 0.783 | 0.006 | 0.653 | 0.233 | 0.783 | 0.007 | 0.795 | 0.001 |
| Otitis media | 0.788 | 0.009 | 0.271 | 0.640 | 0.798 | 0.875 | 0.495 | 0.396 |
| Laryngitis | 0.787 | 0.994 | 0.953 | 0.012 | 0.758 | 0.007 | 0.886 | 0.005 |
| Rhinopharyngitis | 0.953 | 0.002 | -0.625 | 0.260 | 0.791 | 0.002 | 0.788 | 0.003 |
| Tonsillitis/Adenoiditis | 0.759 | 0.005 | 0.766 | 0.131 | 0.832 | 0.009 | 0.724 | 0.005 |
| Pharyngitis | 0.713 | 0.006 | -0.131 | 0.833 | 0.931 | 0.007 | 0.813 | 0.001 |
| Rhinitis | 0.855 | 0.005 | -0.395 | 0.511 | 0.769 | 0.007 | 0.744 | 0.004 |

*r = Pearson correlation coefficient; p = significance value. Bolded p-values < 0.05 indicate statistically significant correlations*

The results in Table 4 indicate strong positive correlations between $SO_2$, $NO_2$, and suspended dust concentrations with nearly all types of acute upper respiratory tract infections, particularly rhinitis (r = 0.855), pharyngitis (r = 0.931 with $NO_2$), and rhinopharyngitis (r = 0.953 with $SO_2$). Most of these correlations were statistically significant ($p < 0.05$), suggesting

a robust association between increased air pollution and disease incidence.

Conversely, carbon monoxide (CO) showed inconsistent and largely non-significant correlations, with negative or weak associations for several conditions, such as rhinitis (r = -0.395, p = 0.511) and pharyngitis (r = -0.131, p = 0.833). This aligns with earlier findings that $SO_2$, $NO_2$, and particulate matter are more critical contributors to airway inflammation than CO.

## IV. DISCUSSION

The analysis of air quality data in Hai Phong from 2017 to 2021 revealed significant temporal variations in pollutant concentrations and their potential impact on respiratory health. As shown in Table 2, the levels of sulfur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) exceeded the national allowable limits (QCVN 05:2013/BTNMT) during 2017-2019 but declined below thresholds from 2020 onward. This improvement may be partly attributed to pandemic-related restrictions that reduced industrial and transportation activities. In contrast, carbon monoxide (CO) concentrations remained consistently within the permissible limit throughout the study period. However, total suspended particulate matter (TSP) remained elevated in all years, with the highest concentration observed in 2019 (398 µg/m³), exceeding the national guideline of 300 µg/m³.

The disease burden data revealed that acute upper respiratory tract infections (URTIs) were most prevalent between 2017 and 2019, with notable conditions including pharyngitis (66,006 cases), rhinitis (24,552 cases), adenoiditis (27,095 cases), and rhinopharyngitis (23,739 cases). A marked decrease in reported cases was observed from 2020 onward, likely influenced by widespread mask-wearing, reduced mobility, and social distancing measures introduced during the COVID-19 pandemic. This trend aligns with national observations of declining respiratory infection rates during the same period.

Correlation analysis using Pearson's coefficients (Table 3) confirmed statistically significant positive relationships between $SO_2$, $NO_2$, and TSP levels and the incidence of several URTIs. Notably, strong correlations were observed for rhinitis ($SO_2$: r = 0.855, p = 0.005; TSP: r = 0.744, p = 0.004), pharyngitis ($NO_2$: r = 0.931, p = 0.007), and sinusitis (TSP: r = 0.795, p = 0.001). These findings are consistent with existing literature linking ambient air pollution with increased respiratory morbidity. In contrast, carbon monoxide showed no significant correlation with URTI outcomes, which supports the view that CO, though harmful at high concentrations, may play a limited role in acute inflammatory airway diseases at ambient levels.

Our findings correspond with those of Nhung et al. (2018), who reported a significant association between ambient $NO_2$ and hospitalization for lower respiratory tract infections among children in Hanoi. Specifically, each 21.9 µg/m³ increase in $NO_2$ concentration was associated with a 6.1% increase in pneumonia-related admissions.[10] While our study focused on upper respiratory conditions, the consistent significance of $NO_2$ across studies highlights its importance as a respiratory irritant.

Similarly, Luong et al. (2017) emphasized the impact of particulate matter ($PM_{10}$, $PM_{2.5}$, and $PM_1$) on pediatric hospitalizations for respiratory disease in Hanoi, with increases in PM levels leading to 1.4 - 2.5% higher admission rates. Our study, although not differentiating particle sizes, showed a significant correlation between TSP and multiple URTIs, notably sinusitis and

rhinopharyngitis - suggesting that airborne particulates of all sizes may contribute to upper airway inflammation.[11]

These findings hold practical relevance in the context of current environmental and public health policy in Vietnam. The Vietnamese government has issued National Action Plans on Air Quality Management to 2025 and Vision to 2030, aiming to reduce pollution in urban centers.[12] In Hai Phong, local authorities have deployed ambient air monitoring stations and initiated green urban development policies. However, the persistent exceedance of TSP and the epidemiological burden of URTIs underscore the need for integrated, community-level health education and more stringent emission control - particularly in industrial and high-traffic zones.

Effective interventions must combine real-time air quality communication, behavior change initiatives (such as promoting mask use and indoor air protection), and infrastructure improvements to mitigate emissions at source. In this regard, collaboration between health and environmental sectors, as well as leveraging tools like the National Environmental Reporting Platform, can empower residents to participate in air quality management.

**Limitation:** This study has limitations that should be acknowledged. Due to the ecological design and the use of secondary data sources, we were unable to stratify the study population by individual-level exposure risks such as smoking status, occupational exposure, pre-existing health conditions, or socioeconomic status. Therefore, the associations observed between air pollution and upper respiratory disease incidence should be interpreted as correlations at the population level, rather than evidence of direct causality. However, the findings highlight important trends that warrant further investigation. Future research should consider longitudinal designs and incorporate individual exposure data to more accurately quantify the risk attributable to air pollution, while adjusting for potential confounding variables.

## V. CONCLUSION

This study confirmed a significant correlation between $SO_2$, $NO_2$, and TSP concentrations and the incidence of acute upper respiratory tract infections in Hai Phong from 2017 to 2021. Elevated pollutant levels during 2017 - 2019 paralleled peaks in pharyngitis, rhinitis, and adenoiditis cases, while correlation coefficients for key pollutants exceeded 0.75 for several diseases.

These findings reinforce national and global evidence on the health risks of air pollution and highlight the need for strengthened emission control, expanded monitoring, and targeted community health education to mitigate respiratory disease burdens in urban environments.

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