ORIGINAL ARTICLE

# Acute Effect of Particulate Matter 2.5 (PM2.5) on Acute Upper Respiratory Tract Infection in Chiang Mai, Thailand

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**Background:** Air pollution, especially PM2.5, is one of the most concerning problems around the world, leading to health problems. There are few studies on acute upper respiratory tract infection (URTI), especially in adults.

**Objective:** To investigate the association between PM2.5 and acute URTI.

**Materials and Methods:** Retrospective data analyses of patients between 2017 and 2019 who visited the outpatient department in Maharaj Nakorn Chiang Mai Hospital with acute URTI was performed. The authors also collected the daily data of PM2.5, PM10, $O_3$, $NO_2$, temperature, and humidity from the center of Chiang Mai Province. The Pearson correlation method was used to identify correlations between acute URTI and those variables.

**Results:** The data of 104,711 patients with acute URTI were collected. Acute nasopharyngitis, acute pharyngitis, and acute tonsillitis were the three most common diseases. The highest level of PM2.5 each year was in January to February. The results were also the same for PM10, $O_3$, and $NO_2$. The present study revealed that PM2.5 had a significant correlation with number of acute respiratory infection patients, r=0.17 ($p<0.001$), which meant higher level of PM2.5 was associated with higher number of patients. The results were also the same for PM10, $O_3$, and $NO_2$. For temperature and humidity, the results were the opposite correlations, which meant the higher the temperature and humidity, the fewer patients were observed that day. The present study also found the regression question, which was every 1 point higher of PM2.5, there would be 19% more patients that day.

**Conclusion:** There was a relationship between pollution, especially PM2.5 and acute URTI. The higher level of PM2.5 is related to an increased number of URTI patients. It is the same results for PM10, $O_3$, and $NO_2$.

**Keywords:** Fine particulate matter; PM2.5; Acute upper respiratory tract infections

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Air pollution is one of the most concerning problems around the world these days, leading to health problems such as respiratory diseases[1,2] and cardiovascular diseases[3-5] causing morbidity and mortality[4,6,7]. Particulate matter (PM) is a type of air pollutant that has been measured and can be defined in different categorizations such as PM10 for less than 10 μm aerodynamic diameter and PM2.5 for less than 2.5 μm aerodynamic diameter. PM2.5 is also known as fine PM. There are also other types of toxic gas that are contained in the atmosphere such as ozone ($O_3$) and nitrogen dioxide ($NO_2$).

Thailand is an agricultural country that produces food crops such as rice, corn, and sugarcane. Harvest season is usually around November to January. After harvesting the crops, farmers usually clear up the leftovers by burning them to prepare the land for the new planting season, causing air pollution at the beginning of the year.

Thailand is located near the Equator causing a hot humid climate and has three seasons, summer in mid-February to mid-May, rainy season in mid-May to mid-October, and winter in mid-October to mid-February. Chiang Mai where the present study was conducted, is one of the provinces located in the north of Thailand. Looking at the geography, Chiang Mai is surrounded by mountains. This interferes with the air ventilation, especially in winter when high atmospheric pressure covers the province, causing pollution problems and making Chiang Mai one of the most polluted cities in the world[8]. This problem still has not been solved, so the present study's objective was to investigate the effect of air pollution,

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especially PM2.5 on acute upper respiratory tract infections.

The upper airway not only provides air passage to the lungs but also heats, humidifies, and filters the air and involves olfaction, swallowing, and speech. The upper airway exposed to cold weather, low humidity, and bad air quality can lead to inflammation and be vulnerable to infection.

Acute upper respiratory tract infection is one of the most common diseases found in outpatient departments, which includes infection of the nasal cavity down to the level of the trachea. The most common pathogens are viruses such as rhinovirus, adenovirus, coronavirus, influenza virus, parainfluenza virus, and bacteria such as group A beta-hemolytic streptococci (GABHS)[9]. The present study showed the three most common diseases regarding the International Classification of Diseases version 10 (ICD-10) were acute nasopharyngitis, acute pharyngitis, and acute tonsillitis.

Studies have reported a positive relationship between PM2.5 and health in many countries but there are few studies on acute upper respiratory tract infection[10,11]. Most were about acute lower respiratory tract infections[1,2] especially in children[12-19]. No study has reported that Thailand is ranked as one of the most polluted countries in the world. Therefore, the authors aimed to explore the effect of air pollution, especially PM2.5 on acute upper respiratory tract infections.

**Table 1.** Data of patients diagnosed with acute upper respiratory tract infection based on the International Classification of Diseases (ICD) version 10 from 2017-2019 in Maharaj Nakorn Chiang Mai Hospital

| Diagnosis | 2017 | 2018 | 2019 |
|---|---|---|---|
| Acute nasopharyngitis | 17,539 | 16,762 | 19,221 |
| Acute maxillary sinusitis | 487 | 367 | 514 |
| Acute frontal sinusitis | 112 | 67 | 85 |
| Acute ethmoid sinusitis | 53 | 32 | 38 |
| Acute sphenoid sinusitis | 41 | 34 | 27 |
| Acute pansinusitis | 293 | 134 | 175 |
| Other acute sinusitis | 717 | 370 | 446 |
| Acute sinusitis, unspecified | 786 | 572 | 742 |
| Streptococcal pharyngitis | 223 | 152 | 240 |
| Acute pharyngitis due to other specified organisms | 262 | 180 | 193 |
| Acute pharyngitis, unspecified | 9,577 | 7,125 | 6,590 |
| Streptococcal tonsillitis | 234 | 182 | 594 |
| Acute tonsillitis due to other specified organisms | 164 | 250 | 250 |
| Acute tonsillitis, unspecified | 4,275 | 3,312 | 3,136 |
| Acute laryngitis | 182 | 127 | 188 |
| Acute tracheitis | 14 | 12 | 45 |
| Acute Laryngotracheitis | 7 | 2 | 8 |
| Acute obstructive laryngitis (croup) | 77 | 25 | 40 |
| Acute epiglottitis | 3 | 4 | 11 |
| Acute laryngopharyngitis | 210 | 124 | 279 |
| Other acute upper respiratory infection of multiple sites | 19 | 10 | 47 |
| Acute upper respiratory infection, unspecified | 2,555 | 1,865 | 2,304 |
| Total | 37,830 | 31,708 | 35,173 |

## Materials and Methods

Retrospective analyses of the data of 104,711 patients including 37,830, 31,708, and 35,173 patients in 2017, 2018, and 2019, respectively, who visited the Outpatient Department in Maharaj Nakorn Chiang Mai Hospital, Faculty of Medicine, Chiang Mai University with acute upper respiratory tract infection were performed. The authors collected all data from the electronic outpatient card system with no bias. The present study hospital is a government tertiary care center and a university hospital having about 1,000,000 visits per year. This study was approved by the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University and all methods were in accordance with relevant guidelines and regulations.

In many countries, when people get an acute upper respiratory tract infection, they do not usually visit the hospital right away. When they need to see the doctor, appointments are needed beforehand. As a result, it is difficult to demonstrate the acute relationship between PM2.5 and daily total hospital visits for acute upper respiratory tract infection. In Thailand, medical services are always available, and generally unscheduled. People who get sick can go to the hospital right away. So, the hospital visiting records in Thailand can provide reliable information on acute upper respiratory tract infection morbidity.

The authors collected the data of patients diagnosed with acute upper respiratory tract infections, based on the ICD-10, as shown in Table 1. At the same time, the authors also collected data on PM2.5, PM10, $O_3$, and $NO_2$ every day between 2017 and 2019. Previous studies have shown that temperature and humidity are potential confounders of the association between ambient air pollution and diseases. Average temperature and average humidity data are also collected. In the present study PM2.5 and PM10 were reported as Air Quality Index (AQI), which was collected from https://aqicn.org/

city/chiang-mai/[20]. $O_3$ and $NO_2$ data were also collected from this website. Average temperature and average humidity data were collected from www.wunderground.com[21].

Previous studies have also reported that ambient air quality data can be used as a proxy for personal exposure among individuals living within 40 kilometers from the monitoring station[4,5]. Therefore, the authors chose the monitoring station near the authors' hospital since most of the patients lived around the city of Chiang Mai and the data usually did not vary within a week, so the authors decided to use the data of the day they visited.

### Statistical analysis

Statistical analysis was performed using Stata Statistical Software, version 16 (StataCorp LLC, College Station, TX, USA). The Pearson correlation method was used to identify correlations between acute respiratory tract infection and PM2.5, PM10, $O_3$, $NO_2$, temperature, and humidity. The p-value less than 0.05 was considered statistically significant.

## Results

The present study collected the data from 104,711 patients who visited the author's hospital diagnosed with acute upper respiratory tract infections in the Outpatient, Inpatient, and Emergency Departments. Acute nasopharyngitis, acute pharyngitis, and acute tonsillitis were the three most common diseases diagnosed in the present study.

Figure 1 shows the relationship between the average of PM2.5 and the number of patients each month. The highest level of PM2.5 each year was in January to February and the second peak was in May to June. The highest level was AQI 167, which was the average PM2.5 level in January 2019.

The level of PM10, $O_3$, and $NO_2$ also peaked in January, which correlated with the level of 2.5 as the graph has a similar pattern (Figure 2).

Figure 3 shows the relationship between average temperature, average humidity, and the number of patients each month.

From the present study using the Pearson correlation method, PM2.5 correlated with the number of acute respiratory infections. The Pearson correlation coefficient (r)=0.17 ($p<0.001$) meant that the higher level of PM2.5, the higher number of patients. Also, PM10, $O_3$, $NO_2$ had correlations with the number of patients as well, r=0.15 ($p<0.001$), r=0.08 (p=0.01), and r=0.21 ($p<0.001$), respectively, as seen in Figure 4.

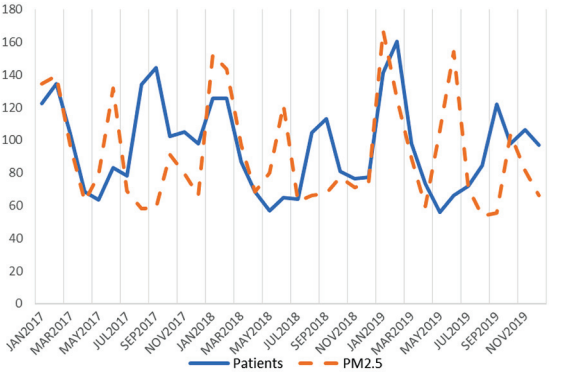



**Figure 1.** Relationship between PM2.5 (in AQI) and the number of patients.

Data from https://aqicn.org/city/chiang-mai/, and hospital database

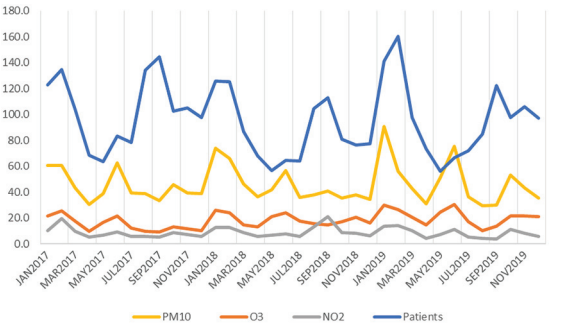



**Figure 2.** Relationship between PM10, $O_3$, $NO_2$ (in AQI), and the number of patients.

Data from www.wunderground.com, and hospital database

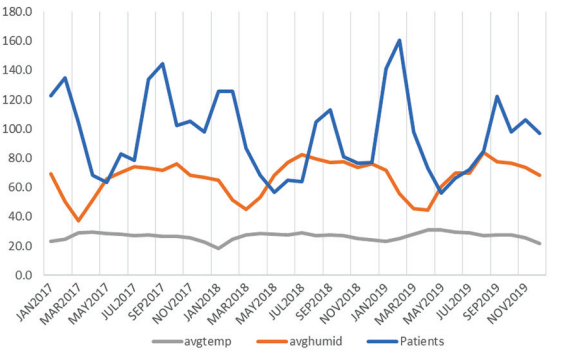
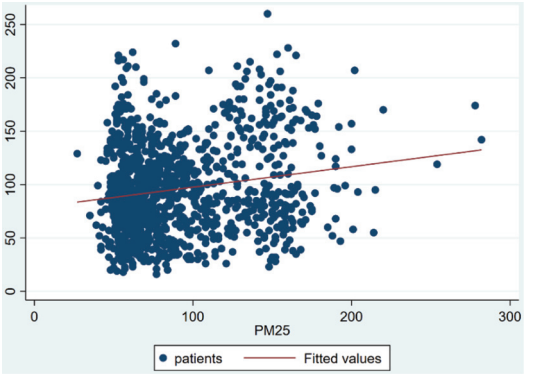


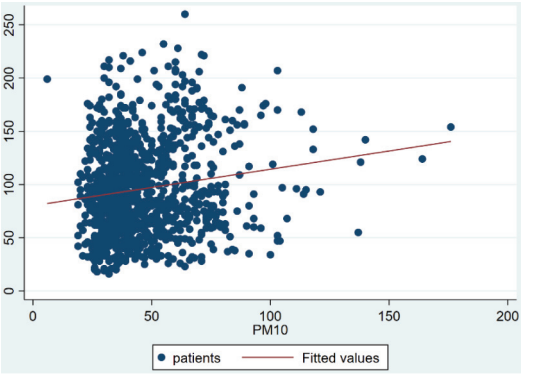

**Figure 3.** Relationship between average temperature (°C), average humidity (%), and the number of patients.

For temperature and humidity, the opposite correlations meant the higher the temperature and humidity, the fewer patients observed that day, r=–0.30 ($p<0.001$) and r=–0.04 (p=0.22), respectively, as seen in Figure 5.

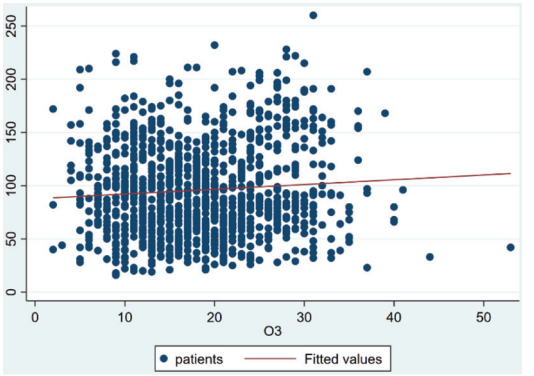
Regression analysis was done between patients



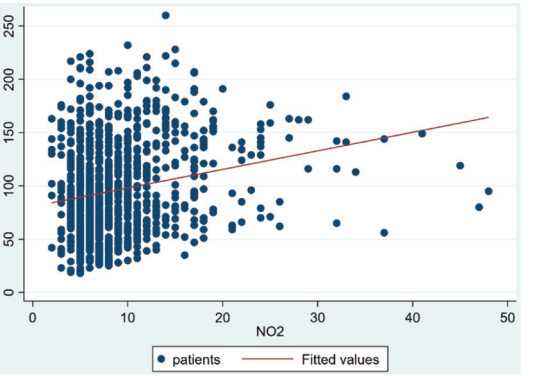

PM2.5, r=0.17 (p<0.001)




PM10, r=0.15 (p<0.001)

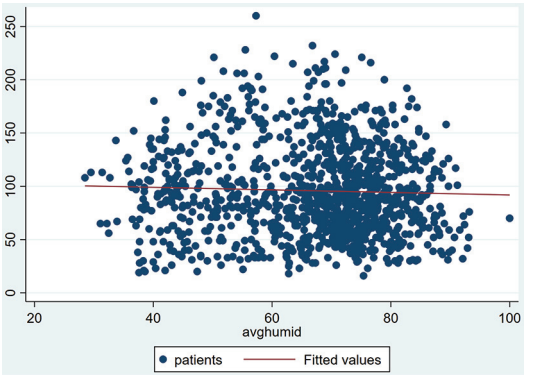



$O_3$ r=0.08 (p=0.01)

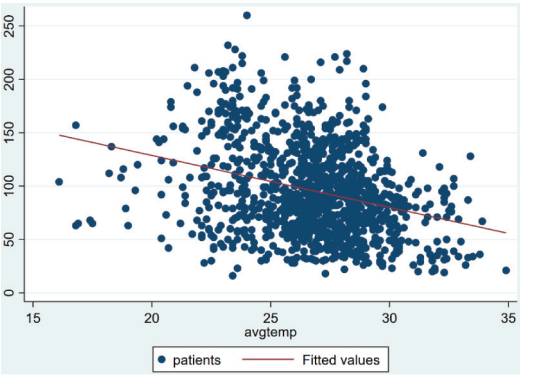



$NO_2$ r=0.21 (p<0.001)

**Figure 4.** Correlations between acute respiratory infections and PM2.5, PM10, $O_3$, and $NO_2$, respectively, shown as the Pearson correlation coefficient (r).




Average temperature, r=–0.30 (p<0.001)




Average humidity, r=–0.04 (p=0.22)

**Figure 5.** Correlations between acute respiratory infections, average temperature, and average humidity, shown as the Pearson correlation coefficient (r).

and PM2.5 and found that the regression equation was Patients = 78.4+0.19 (PM2.5). Therefore, for every 1 point higher of PM2.5, there would be 19% more patients on that day. The authors could not perform multivariable regression including PM10, $O_3$, and $NO_2$ due to correlations with PM2.5 in AQI form that interfered with the result.

## Discussion

In the present study, a significant correlation was found between PM2.5 and acute upper respiratory tract infections similar to previous studies[13,17,22]. The higher level of PM2.5 was significantly associated with a higher number of patients. For temperature and humidity, opposite correlations were found, which

meant the higher the temperature and humidity, the fewer patients visited the hospital on those days. The result was significant for temperature but not for humidity. The result was similar compared to a previous study that there was a stronger association between PM2.5 levels and acute upper respiratory infections in cold seasons[23].

Most previous studies have reported hospital admission from severe cases of respiratory infection. However, few have studied total hospital utilization and outpatient visits that could reflect the real number of patients and observable immediate relationship between PM2.5 and hospital utilization[7,14]. Previous studies on children also showed the relationship between PM2.5 and acute upper respiratory tract infections[17-19]. The present study is the first study on the children and adult population in Thailand to estimate the effects of short-term PM2.5 exposures on acute upper respiratory tract infections. A previous study found a positive and delayed relationship between daily PM2.5 concentrations and hospital admissions for upper respiratory tract infections but no evidence of associations between PM2.5 and total hospital utilization, outpatient visits, or emergency room visits was observed[10].

The highest level of PM2.5 each year was in January-February, which was the end of the harvest season when farmers usually burnt the leftover crops, and the higher level of PM2.5 was related to an increased number of patients. PM2.5 was also high in May to June, which was the summer to the beginning of the rainy season in Thailand. The weather was hot and dry, so it tended to have wildfires that caused PM2.5. On the other hand, the number of patients decreased in May. This might be explained by the higher temperature. Despite the lower level of PM2.5, the higher number of patients around September could be explained by influenza season in Thailand, which peaked in the rainy season from May to September.

There are limitations in the present study. Firstly, all patient visits were collected but did not distinguish between first visits, revisits, and visits for follow-up, which could lead to a higher number of diagnoses. The authors also collected the data on the visit day and did not collect data from the day prior, which some studies claimed that there was an association between PM2.5 level and adverse health effects beyond three days, so they used a distributed lag model to estimate the immediate and lagged effects of PM2.5. Lastly, since the authors collected the data of PM2.5 as AQI, which was widely more available, the authors could not perform multivariable regression including PM10, $O_3$, and $NO_2$ due to correlations with PM2.5 that interfered with the result. Therefore, it is better to collect PM2.5 data as $\mu g/m^3$ to eliminate the relationship between other variables.

## Conclusion

There was a relationship between pollution, especially PM2.5, and acute upper respiratory tract infections. The higher level of PM2.5 is related to an increased number of patients. The same result can be seen for PM10, $O_3$, and $NO_2$.

## What is already known on this topic?

There are few studies on acute upper respiratory tract infection, especially in adults. This study aimed to investigate the association between PM2.5 and acute upper respiratory tract infection.

## What does this study add?

There was a relationship between pollution, especially PM2.5, and acute upper respiratory tract infections. The higher level of PM2.5 is related to an increased number of patients visiting the hospital, so this study could raise awareness and protection during PM2.5 season in Thailand and other countries that encounter pollution problems.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## Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.


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## Conflicts of interest

The authors declare no conflict of interest.

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