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AN ASSESSMENT OF ANNUAL RESPIRATORY DISEASE ATTRIBUTABLE TO AMBIENT PM2.5 IN NORTHERN REGION, THAILAND

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ABSTRACT:

PM2.5 is among the air pollutants that pose a significant health risk to the population, particularly in the northern region of Thailand, where the average concentration of PM2.5 exceeds both Thai standards (15µ/m3) and those set by the World Health Organization (WHO) standards (5µ/m3). The objective of this research is to assess the health impact of PM2.5 on the number of respiratory disease patients in the northern region of Thailand in 2023, utilizing the Environmental Benefits Mapping and Analysis Program (BenMAP). It was found that elevated levels of PM2.5 significantly increased the number of respiratory disease patients. In 2023, the northern region recorded a total of 126,484 respiratory disease patients, including both males and females. However, upon analysis, it was determined that controlling PM2.5 levels to meet Thai and WHO standards could help reduce the occurrence of respiratory diseases. Specifically, it could decrease the number of patients to 13,049, representing a 10.36% reduction, and to 19,367, representing a 15.38% reduction, respectively. The results of this research may provide valuable data to support the development of policies and measures aimed at reducing air pollution, there by sustainably reducing its adverse health impacts on the population in the northern region of Thailand.

Keywords: BenMAP, Northern region of Thailand, PM2.5, Respiratory Disease Patients

1. INTRODUCTION

In the upper northern region of Thailand, persistent statistical analyses reveal a concerning trend: $PM_{2.5}$ levels have consistently exceeded established safety standards over an extended period [1]. This chronic air pollution issue has significantly impacted the health and well-being of residents in the area [2]. This study is dedicated to scrutinizing the repercussions of elevated $PM_{2.5}$ levels on respiratory health within Northern Thailand throughout the year 2023. To achieve this objective, the Environmental Benefits Mapping and Analysis Program (BenMAP) serves as an invaluable tool for evaluating health outcomes [3]. Methodologically, this research entails a rigorous process of data collection and analysis. Essential datasets, including $PM_{2.5}$ concentration data sourced from the Department of Pollution Control [4], population figures specific to the Northern Thailand region [5], and respiratory disease case numbers obtained from the Ministry of Public Health [6], are meticulously gathered, and scrutinized. These datasets serve as the foundation for analyzing health outcomes associated with $PM_{2.5}$ exposure [3]. Central to the analytical approach is the generation of comprehensive health impact maps utilizing BenMAP software. These visual representations enable a nuanced understanding and assessment of the health effects stemming from $PM_{2.5}$ pollution on the local population [7]. Of particular emphasis is the examination of respiratory disease incidence and its distribution across diverse age demographics. The insights gleaned from this study are poised to significantly enhance our understanding of the health implications of $PM_{2.5}$ exposure in Northern Thailand. Moreover, these findings hold the potential to inform the development of evidence-based policies and strategic interventions aimed at ameliorating the adverse impacts of poor air quality [8]. By

shedding light on the specific health outcomes associated with $PM_{2.5}$ pollution, this research endeavors to catalyze concerted efforts towards fostering a healthier and more sustainable environment in the upper northern region of Thailand.

2. METHODOLOGY

A. Study area

In this study, the authors utilized observed $PM_{2.5}$ data from eight locations in northern Thailand, including Chiang Mai, Chiang Rai, Lamphun, Lampang, Phrae, Nan, Mae Hong Son, and Phayao, as provided by the Thai Pollution Control Department for the year 2023. The study area is depicted in Fig. 1. The locations of the monitoring stations in these eight provinces of upper northern Thailand are shown in Fig. 2 and listed in Table I.

Fig. 1 Study area.

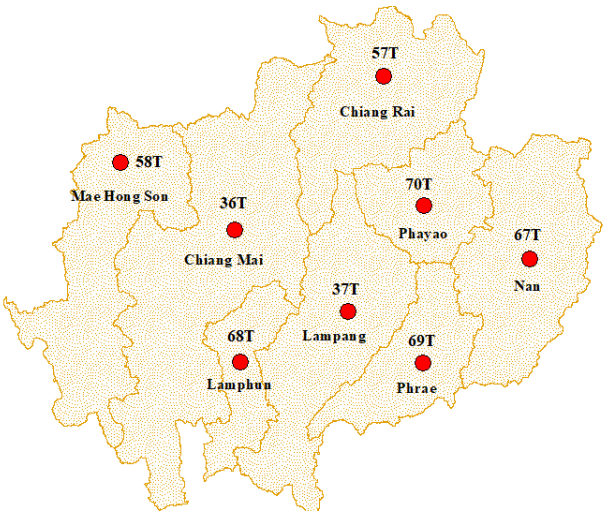

Fig. 2 $PM_{2.5}$ monitoring station in northern of Thailand.

Table I. The statistical data of $PM_{2.5}$ monitoring station in 8 provinces in northern Thailand, 2023

Province	PCD station	Latitude	Longitude
Chiang Mai	36T	18.84063	98.96966
Lampang	37T	18.27825	99.50645
Chiang Rai	57T	19.90924	99.82336
Mae Hong Son	58T	19.30469	97.97100
Nan	67T	18.78888	100.7764
Lamphun	68T	18.56718	99.03856
Phrae	69T	18.12893	100.1623
Phayao	70T	19.20023	99.89305

B. Estimating Human Health Impacts

To assess the effects of $PM_{2.5}$ on human health, equation (1) was employed to compute the number of individuals who avoided respiratory disease [3]:

$$\Delta Y = Yo\,(1 - e^{-\beta \Delta PM2.5}) * Pop, \qquad (1)$$

$\Delta PM_{2.5}$ represents the change in $PM_{2.5}$ concentration to a target or health standard value. Pop refers to the number of people in northern Thailand at risk of exposure to $PM_{2.5}$, aged 0 and above, as listed in Table II. The health effect estimate (β) is the percentage change in the risk of severe health effects caused by a one-unit change in ambient air pollution. Epidemiological studies provide excellent sources for effect estimates [3]. This study examined the number of respiratory diseases caused by $PM_{2.5}$ in northern Thailand. The age range of the population is from 0 years and older, with a beta value of 0.005164 representing health effect estimates for the northern region [9]. The health effect estimate equation is presented in Equation (2):

$$\beta = \log\left(\frac{\text{epide miology}}{\Delta PM}\right), \qquad (2)$$

Lastly, the health baseline incidence (Y0) estimates the average annual number of respiratory disease patients [3]. It was derived from the ratio of respiratory disease cases to the total

population in upper northern Thailand, spanning from age 0 and above, as detailed in Table II. Y0 was calculated using the equation (3) below:

(3) $$Y_0 = \frac{\text{Number of cases}}{\text{Total population}}.$$

Table II. The total population and the number of respiratory diseases cases in northern Thailand, 2023

Province	Population		Respiratory causes	
	Male	Female	Male	Female
Chiang Mai	570,482	607,413	29,858	32,146
Lampang	255,135	276,101	9,880	10,309
Chiang Rai	443,819	462,389	5,277	5,952
Mae Hong Son	92,354	91,753	1,630	1,834
Nan	173,892	178,391	1,844	2,035
Lamphun	165,427	178,116	7,709	7,793
Phrae	152,576	167,752	2,014	2,343
Phayao	168,312	179,878	2,465	2,834

3. RESULTS AND DISCUSSION

C. Concentration of $PM_{2.5}$ in Northern Thailand

In the investigation of $PM_{2.5}$ concentrations in the upper northern region of Thailand, there are a total of eight provinces, each represented by one station. Analysis shows that the daily average $PM_{2.5}$ concentration in this region does not exceed the 24-hour standard set by the Department of Pollution Control, which is 37.5 µg/m³ [10]. However, findings from Fig. 3 indicate that the annual average $PM_{2.5}$ concentration at these 8 stations exceeds the annual standard established by the Department of Pollution Control, which is 15 µg/m^3 [10], at each station. Particularly in March, the daily $PM_{2.5}$ concentration reached as high as 374 µg/m^3 in Chiang Rai province (57T), posing health risks to the local population. This is attributed to extensive biomass burning in the upper northern region of Thailand, as well as the influence of transboundary particulate matter and greenhouse gas emissions from neighboring countries [11]. Furthermore, agricultural practices, such as crop residue burning and livestock farming, contribute to the release of particulate matter and other pollutants into the air [12]. These activities are prevalent in rural areas of the upper northern region, exacerbating air quality issues. Subsequently, the daily $PM_{2.5}$ concentration gradually decreases, reaching its lowest levels in July-August due to heavy rainfall across the northern region of Thailand, which helps to disperse suspended particulate matter in the atmosphere. However, it gradually rises again starting from December, recurring in this pattern annually. The annual average $PM_{2.5}$ concentration ranges between 32.85-38.75µg/m^3, as depicted in Fig. 4.

The study found that the average concentration of $PM_{2.5}$ exceeds both the annual Thailand standards (15 µ/m³) and those set by the annual World Health Organization (WHO) standards (5 µ/m³) [13]. As shown in Fig. 3.

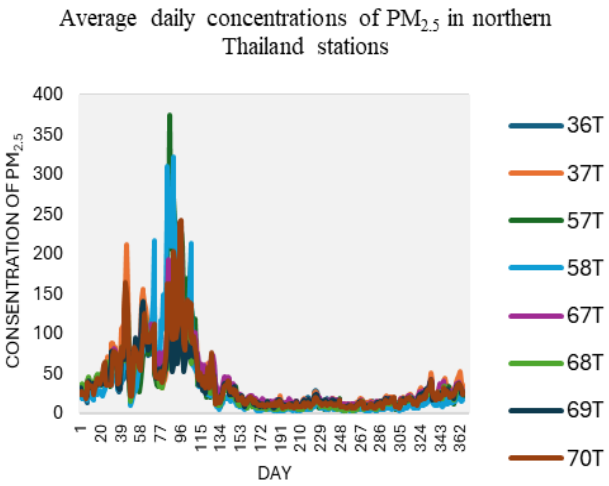

Fig. 3 The daily average concentration of $PM_{2.5}$ at each station in 8 provinces, northern of Thailand.

It was observed that during March-May 2023, $PM_{2.5}$ values exceeded both the daily Thailand (37.5µ/m³) and WHO (15µ/m³) standard values at every station.

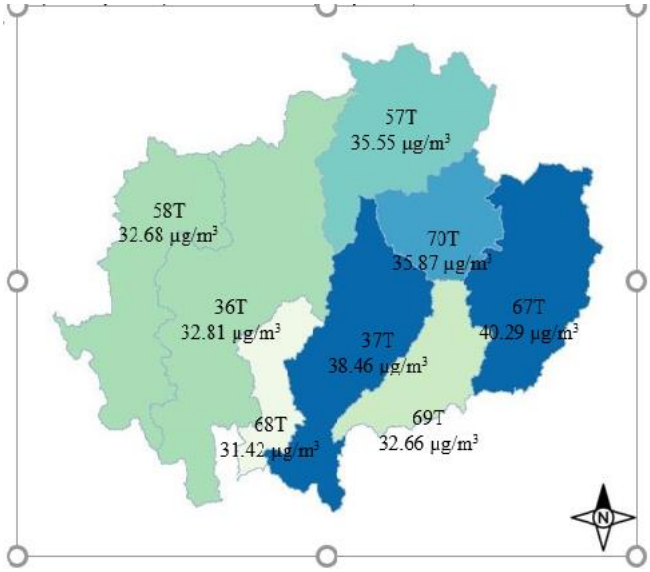

Fig. 4 Concentrations of Annual average $PM_{2.5}$ in northern Thailand, 2023.

D. Health Impact Assessment

It was found that elevated levels of $PM_{2.5}$ significantly increased the number of respiratory disease patients. Table III shows in 2023, the northern region recorded a total of 125,923 respiratory disease patients, including both males and females. However, upon analysis, it was determined that controlling $PM_{2.5}$ levels to meet Thailand and WHO standards could help reduce the occurrence of respiratory diseases. Specifically, it could decrease the number of patients to 13,049 representing a 10.36% reduction, and to 19,367 representing a 15.38% reduction, respectively. If $PM_{2.5}$ levels are controlled to not exceed the annual average $PM_{2.5}$ value according to Thailand guideline (15 µg/m³) in each province, the number of respiratory

disease cases could be reduced as follows: Chiang Mai 5,644 cases (43.25%), Lamphun 2,016 cases (15.45%), Lampang 2,299 cases (17.62%), Phrae 595 cases (4.56%), Nan 379 cases (2.90%), Phayao 515 cases (3.95%), Chiang Rai 1,262 cases (9.67%), and Mae Hong Son 339 cases (2.60%). Furthermore, if the levels are controlled to not exceed the control annual average $PM_{2.5}$ value according to the WHO guideline (5 µg/m^3) in each province, the number of respiratory disease cases could be reduced as follows: Chiang Mai 8,790 cases (45.39%), Lamphun 2,789 cases (14.40%), Lampang 3,296 cases (17.02%), Phrae 805 cases (4.16%), Nan 574 cases (2.96%), Phayao 782 cases (4.04%), Chiang Rai 1,818 cases (9.39%), and Mae Hong Son cases 513 cases (2.65%). The findings of this study can provide valuable data to support the development of policies and measures aimed at reducing air pollution, thereby sustainably reducing its adverse health impacts on the population in the northern region of Thailand.

Table III. Number of people avoid respiratory disease illnesses by controlling $PM_{2.5}$ in 2023.

Province	Control Annual average $PM_{2.5}$		Total Patient
	Thailand (15µ/m³)	WHO (5µ/m³)	
Chiang Mai	5,644	8,790	62,004
Lamphun	2,016	2,789	15,502
Lampang	2,299	3,296	20,189
Phrae	595	805	4,357
Nan	379	574	3,879
Phayao	515	782	5,299
Chiang Rai	1,262	1,818	11,229
Mae Hong Son	339	513	3,464
Total	13,049	19,367	125,923

4. CONCLUSION

This research assesses the impact of $PM_{2.5}$ on respiratory disease patients in northern Thailand in 2023 using the BenMAP. Results showed $PM_{2.5}$ significantly affects respiratory health, with Chiang Mai experiencing the highest cases and Chiang Rai found the highest daily concentration of $PM_{2.5}$ at 374 µg/m³, exceeding the 24-hour guideline of 37.5 µg/m³. Controlling $PM_{2.5}$ to 15 µg/m³ could reduce respiratory patients by 10.36%, and to 5 µg/m³ by 15.38%. Lowering $PM_{2.5}$ levels would greatly benefit public health. High pollution levels remain a critical issue, indicating the need for further studies using BenMAP-CE to evaluate other pollutants.

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