

# PM2.5 Pollution and its Impact on Public Health in Thailand: Public Satisfaction with Government Initiatives

N. Vattanaprateep

*Department of Civil Engineering, Bangkokthonburi University, Bangkok 10700, Thailand*

(Received 27 August, 2023; Accepted 22 October, 2023)

## ABSTRACT

The battle against PM2.5 pollution in Thailand presents an urgent and intricate challenge with far-reaching implications for public health. Stemming from diverse sources, PM2.5 pollution threatens the well-being of Thai citizens, infiltrating their respiratory systems and precipitating a spectrum of health problems, from aggravated asthma to cardiovascular diseases and, tragically, premature mortality. This research underscores the government's significant measures to regulate industrial emissions, promote clean energy, and enhance public awareness. Data highlights a majority of respondents (82.75%) are aware of the health risks associated with PM2.5 pollution, yet a substantial segment (17.25%) remains uninformed. Public satisfaction with government initiatives varies, with 35.50% expressing approval, 33.75% indicating dissatisfaction, and 30.75% adopting a neutral stance. This diversity reflects the complexity of the issue and underscores the need for continued dialogue. Collaborative efforts, public engagement, and clean energy transitions play pivotal roles in propelling progress toward cleaner air and improved public health, emphasizing the interconnectedness of environmental concerns and shared responsibility to protect communities and the planet.

**Key words:**  $PM_{2.5}$  Pollution, Air Pollution, Government Initiatives

## Introduction

The global environmental crisis looms ever larger, casting its long shadow upon the health and well-being of populations worldwide. Among the myriad threats to ecological balance and human health, the specter of fine particulate matter with a diameter of 2.5 micrometers or less, commonly known as PM2.5, haunts the skies of nations and endangers the lives of their citizens (Jin *et al.*, 2022; Xu *et al.*, 2022). In this article, we embark on an exploration of the insidious relationship between PM2.5 pollution and public health in the context of Thailand, where government initiatives aimed at ameliorating this environmental scourge are of paramount concern. This comprehen-

sive examination delves into the sources and effects of PM2.5 pollution, scrutinizes the policies and actions undertaken by the Thai government to combat it, and gauges the public's satisfaction with these efforts.

## PM<sub>2.5</sub> Pollution

At the heart of this issue lies the invisible enemy - PM2.5. These minuscule particles, no larger than the width of a human hair, are ubiquitous in the modern environment. Originating from a complex web of sources, PM2.5 particles are a hazardous amalgamation of industrial emissions, vehicular exhaust, agricultural activities, and natural sources like dust and wildfires. Their diminutive size, however, is no

reflection of their potential for harm.

PM2.5 particles, due to their minuteness, can infiltrate the deepest recesses of the respiratory system, including the alveoli, where the exchange of oxygen and carbon dioxide occurs. This has dire consequences for human health. Chronic exposure to PM2.5 pollution has been linked to a litany of respiratory and cardiovascular diseases. Acute effects include aggravated asthma, bronchitis, and increased susceptibility to respiratory infections. Long-term exposure elevates the risk of chronic conditions such as lung cancer, heart disease, and reduced life expectancy. As a harbinger of premature death, PM2.5 pollution demands unrelenting attention (Lu *et al.*, 2018).

### Public Health Impacts

In the Thai context, PM2.5 pollution has not spared its population from its pervasive grasp. The nation has grappled with alarming air quality deterioration, especially in urban centers like Bangkok, Chiang Mai, and Chiang Rai. As the pall of particulate matter descends upon the landscape, the health implications become starkly evident. Respiratory problems become endemic, with a surge in hospital admissions due to asthma and other pulmonary ailments. Cardiovascular complications follow suit, as individuals, young and old, experience an increased risk of heart attacks and strokes (Krittawong *et al.*, 2023; Yousefi *et al.*, 2023). The impact extends far beyond immediate health concerns. When the air becomes toxic, the economic toll mounts, as healthcare expenses skyrocket, and workdays are lost due to illness. Parents worry about their children's development and safety, and the elderly are particularly vulnerable to the perils of PM2.5 pollution. Moreover, the overarching anxiety about the long-term health consequences casts a pall over the psyche of the nation. This has provoked a growing sense of urgency, a demand for decisive action, and a scrutiny of government policies designed to mitigate the crisis.

### Government Initiatives

In recognition of the urgency, the Thai government has initiated a series of measures aimed at combating PM2.5 pollution. These measures range from regulatory changes targeting emissions from industries and vehicles to the promotion of clean energy sources and urban green spaces. Such endeavors are a testament to the government's commitment to ad-

ressing the issue and safeguarding public health. However, as the crisis persists, it is crucial to assess the effectiveness of these initiatives, understand the challenges faced by government bodies, and explore the satisfaction levels of the Thai public regarding their government's performance in this battle. The success of these efforts hinges on not only the efficacy of the measures but also on the public's awareness and willingness to participate. In the following sections of this article, we will delve deeper into government policies, public perceptions, and the future prospects for managing PM2.5 pollution in Thailand.

In this multifaceted exploration, we endeavor to provide a comprehensive perspective on the complex interplay between PM2.5 pollution, public health, government action, and societal satisfaction. The tale of Thailand's struggle against PM2.5 pollution serves as a microcosm of the global battle to protect the environment and the health of its inhabitants. Through this inquiry, we hope to shed light on not only the challenges but also the potential solutions that can lead us to cleaner skies and healthier communities.

## Methodology

### Sample Size Determination

For this research, a sample size of 400 individuals was determined using the Yamane formula. With a known population of approximately 70,000,000 in Thailand, the formula allowed for a representative sample that would yield statistically significant results. A margin of error (ee) was set at 5% to ensure a reasonable level of precision in the study.

$$\text{The formula, } n = \frac{N}{1 + Ne^2}$$

where  $n$  represents the sample size,  $N$  is the population size, and  $e$  is the margin of error, was used to calculate the sample size (Yamane, 1967).

### Data Collection

Data for this research was collected through a structured survey conducted across different regions of Thailand. The survey instrument was designed to assess public awareness of the health risks associated with PM2.5 pollution and to gauge public satisfaction with government initiatives aimed at mitigating PM2.5 pollution.

The survey consisted of closed-ended questions

to elicit specific responses related to awareness and satisfaction levels. A team of trained surveyors administered the surveys, ensuring consistency and accuracy in data collection.

### Sampling Technique

A stratified random sampling technique was employed to ensure that the sample represented various demographics and regions within Thailand accurately. Stratification involved dividing the population into subgroups or strata based on factors such as age, gender, urban or rural residence, and geographic region. Within each stratum, random sampling was conducted to select respondents. This approach aimed to reduce sampling bias and enhance the representativeness of the sample.

### Data Analysis

Data collected from the survey was analyzed using statistical software. Descriptive statistics, such as frequencies and percentages, were computed to summarize and present the data.

Ethical guidelines for research involving human subjects were strictly adhered to throughout the data collection process. Informed consent was obtained from all respondents, ensuring their willingness to participate in the survey. Anonymity and confidentiality were maintained, with no personal identifying information collected.

### Limitations

It is essential to acknowledge certain limitations in this research. First, while the sample size was determined using the Yamane formula to ensure a reasonable level of precision, there is always the potential for sampling error. Second, the data was collected at a specific point in time and may not account for changes in awareness or satisfaction levels over time. Finally, respondents' self-reporting in surveys can introduce response bias.

Overall, the methodology employed in this research seeks to provide a comprehensive understanding of public awareness and satisfaction regarding PM2.5 pollution in Thailand while addressing potential limitations in the sampling and data collection process.

## Results and Discussion

### PM2.5 Pollution

At the heart of the environmental challenge in Thai-

land lies the specter of PM2.5 pollution, which represents fine particulate matter with a diameter of 2.5 micrometers or less. These minuscule particles, often referred to as PM2.5, are at the center of the air quality crisis that has gripped the nation. To address this issue effectively, it is imperative to understand both the sources of PM2.5 pollution and the manner in which these particles impact the environment and public health.

### Sources of PM2.5 Pollution

PM2.5 particles originate from a diverse and intricate web of sources, both anthropogenic and natural. It is this multifaceted origin that contributes to the complexity of the problem in Thailand and many other regions worldwide.

**Table 1.** Source of PM 2.5 pollution.

No.	Effect on	Percent
1	Industrial emissions	42
2	Vehicle exhausts	38
3	Agricultural Activities	11
4	Natural Sources	9

The data presented in Table 1, which details the sources of PM2.5 pollution, is based on the results of a survey conducted in the region. This survey sheds light on the multifaceted origins of PM2.5 (particulate matter with a diameter of 2.5 micrometers or less) pollution, encompassing both anthropogenic and natural sources. The primary sources and their respective percentages, as obtained from the survey, are as follows:

- 1) **Industrial Emissions:** The survey findings reveal that industrial emissions constitute the most significant source of PM2.5 pollution, accounting for 42% of the total pollution in the region. These emissions originate from various industrial processes and activities.
- 2) **Vehicle Exhausts:** According to the survey results, vehicle exhausts represent the second most substantial source, contributing 38% of the total PM2.5 pollution. These emissions stem from the exhaust systems of automobiles, trucks, and motorcycles.
- 3) **Agricultural Activities:** The survey data indicate that agricultural activities, including practices like field burning, contribute to 11% of the total PM2.5 pollution. These activities release particulate matter into the atmosphere.

5) **Natural Sources:** The survey data further reveal that natural sources, such as dust from deserts, wildfires, and other environmental factors, account for 9% of the total PM2.5 pollution.

These survey results underscore the pivotal role of industrial emissions and vehicle exhausts as the predominant sources of PM2.5 pollution in the surveyed region. The survey findings emphasize the importance of understanding these key sources for effective policymaking and interventions aimed at reducing PM2.5 pollution levels and improving air quality and public health.

**Impact on Air Quality and Human Health**

PM2.5 particles, despite their diminutive size, wield a significant impact on air quality and human health. Their small size allows them to remain suspended in the air for extended periods, increasing the potential for exposure. Furthermore, these particles can penetrate deep into the respiratory system and even enter the bloodstream, posing severe health risks.

**Effects on Air Quality**

PM2.5 pollution has a pronounced effect on air quality. High concentrations of these fine particles lead to the formation of haze, reducing visibility and imparting a greyish or smoky appearance to the atmosphere. This reduction in visibility has implications for road safety, aviation, and overall environmental aesthetics.

**Public Health Impacts**

The pervasive presence of PM2.5 pollution in the atmosphere is not a mere environmental concern but a pressing public health crisis. The inhalation of fine particulate matter, with a diameter of 2.5 micrometers or less, poses grave consequences for the health and well-being of individuals and communities, particularly in Thailand. The data presented in Table 2, which outlines the health effects of PM2.5 pollution, is derived from a comprehensive survey conducted in the region. This survey provides criti-

**Table 2.** Health Effects of PM 2.5

No.	Effect on	Percent
1	Respiratory Health	57
2	Cardiovascular Health	15
3	Premature Mortality	6
4	Economic and Social Implications	22

cal insights into the extensive public health impacts of PM2.5 pollution, particularly in the context of Thailand. The survey results reveal a wide spectrum of health consequences associated with PM2.5 pollution and their respective percentages, as follows:

**Respiratory Health**

The respiratory system is one of the primary targets of PM2.5 pollution. These fine particles, when inhaled, can penetrate deep into the lungs, causing various respiratory ailments.

- 1) **Exacerbated Asthma:** Individuals with asthma are particularly vulnerable to PM2.5 pollution. Exposure to these particles can trigger asthma attacks, leading to increased hospitalizations and a reduced quality of life for those affected.
- 2) **Bronchitis:** Chronic exposure to PM2.5 particles can cause bronchitis, characterized by inflamed bronchial tubes. This leads to persistent coughing, difficulty in breathing, and increased susceptibility to respiratory infections.
- 3) **Respiratory Infections:** PM2.5 pollution weakens the respiratory system’s defenses, making individuals more susceptible to respiratory infections such as pneumonia and bronchopneumonia.

The survey data indicate that 57% of the population is affected by respiratory health issues due to PM2.5 pollution. These issues encompass a range of conditions and symptoms related to the respiratory system.

**Cardiovascular Health**

The detrimental effects of PM2.5 pollution extend beyond the respiratory system, encompassing cardiovascular health as well. Long-term exposure to these fine particles has been linked to a range of cardiovascular conditions:

**Heart Disease:** PM2.5 pollution can contribute to the development and exacerbation of heart disease. It promotes inflammation, oxidative stress, and the formation of arterial plaques, increasing the risk of heart attacks and other cardiovascular events.

**Stroke:** Exposure to elevated PM2.5 levels is associated with an increased risk of stroke. These particles can lead to the narrowing and hardening of arteries, making clots more likely to form.

**High Blood Pressure:** PM2.5 pollution has been linked to hypertension (high blood pressure), a significant risk factor for cardiovascular diseases.

According to the survey findings, 15% of the

population is at risk of cardiovascular health problems linked to PM2.5 pollution. These issues include heart-related conditions that can be exacerbated by exposure to fine particulate matter.

### Premature Mortality

The survey results tragically reveal that 6% of all deaths in the region are attributed to PM2.5 pollution. Long-term exposure to elevated levels of PM2.5 has been associated with premature mortality and shortened life expectancy.

### Economic and Social Implications

Beyond direct health effects, the survey data suggest that 22% of the population is impacted by the economic and social implications of PM2.5 pollution. These implications include healthcare costs, productivity losses, and a diminished quality of life.

Moreover, the overarching concern about the long-term health implications of PM2.5 pollution casts a shadow of anxiety over communities. Residents worry about their children's development and the health of the elderly. This anxiety, compounded by a perceived lack of control over air quality, can affect mental health and overall well-being.

### Public Satisfaction and Perceptions

Public satisfaction and perceptions regarding government initiatives to address PM2.5 pollution in Thailand are critical factors that influence the effectiveness and sustainability of these efforts. This section delves into the sentiment of the Thai public, exploring their awareness of the issue, satisfaction with government actions, and concerns about PM2.5 pollution.

### Public Awareness

Awareness of PM2.5 pollution and its implications is a foundational element in addressing the issue. The Thai government has conducted various public awareness campaigns and health education programs to inform citizens about the risks of PM2.5 pollution. However, the level of awareness varies across regions and demographics.

In urban areas, where PM2.5 pollution is often more severe, public awareness tends to be higher. Residents in these regions are more likely to be informed about the health risks and government initiatives. In contrast, rural areas may have lower awareness levels, despite being equally affected by the issue.

**Table 3.** Awareness of effects on human health

Awareness	Frequency	Percent
Yes	331	82.75
No	69	17.25
Total	400	100.00

Table 1 presents a clear picture of public awareness regarding the health effects of PM2.5 pollution. With 82.75% of respondents indicating that they are aware of the health risks associated with PM2.5 pollution, it is evident that a significant majority of the population acknowledges the gravity of the issue. This level of awareness is a positive sign, as informed citizens are better equipped to take precautions and advocate for effective government actions.

However, the 17.25% who reported not being aware of the health risks is a reminder that there is still work to be done in raising awareness among a segment of the population. Public awareness campaigns and educational programs should continue to target these individuals to ensure that the entire community is well-informed and empowered to protect their health.

### Public Satisfaction with Government Initiatives

Public satisfaction with government actions to combat PM2.5 pollution is a nuanced and evolving aspect of the issue. Various factors contribute to public sentiment, including perceived effectiveness, communication, and the tangible impact of government initiatives.

Citizens generally appreciate the government's attempts to address PM2.5 pollution, particularly through the implementation of emission standards and public health advisories. They understand the complexity of the problem and recognize that change takes time. However, there are critical voices that express concerns about the pace and efficacy of government actions.

**Table 4.** Levels of satisfaction with government initiatives.

Level of Satisfaction	Frequency	Percent
Satisfied	142	35.50
Neutral	123	30.75
Dissatisfied	135	33.75
Total	400	100.00

Table 2 sheds light on the varying levels of satisfaction with government initiatives to combat PM2.5 pollution in Thailand. The diversity of opinions

within the population is evident:

- 35.50% of respondents expressed satisfaction with the government's efforts.
- 30.75% indicated a neutral stance, neither strongly approving nor disapproving of government initiatives.
- 33.75% expressed dissatisfaction with government actions.

These statistics emphasize the complexity of the issue and the importance of understanding the diverse perspectives of the population. The data reflects a nation in which a substantial portion is satisfied with government efforts, but another significant segment holds concerns and criticisms about these actions.

Public sentiment is a dynamic and evolving factor, influenced by the effectiveness of government policies, communication, and the tangible impact of initiatives. The data suggests that there is room for improvement in government actions to address the concerns of those who are dissatisfied or neutral.

Addressing the dire public health implications of PM2.5 pollution in Thailand requires a multi-faceted approach, with a significant role played by government initiatives. The Thai government has recognized the gravity of the issue and implemented a range of measures to combat PM2.5 pollution. In this section, we delve into the policies and actions taken by the government in response to this pressing environmental and health challenge.

### Regulatory Changes and Emissions Reduction

The Thai government has taken decisive steps to regulate industrial emissions and reduce air pollution. Key initiatives include:

- 1) **Emission Standards:** Thailand has introduced and revised emission standards for various industries, including power plants and factories. These standards aim to limit the release of particulate matter and other pollutants into the atmosphere, thereby reducing PM2.5 pollution.
- 2) **Vehicle Emission Standards:** The government has set stringent vehicle emission standards to reduce the contribution of transportation to PM2.5 pollution. These standards target vehicle exhaust emissions and promote the adoption of cleaner and more fuel-efficient technologies.

### Promotion of Clean Energy and Alternative Transportation

To combat PM2.5 pollution and reduce the reliance

on fossil fuels, the Thai government has implemented policies to promote clean energy sources and alternative transportation methods:

- 1) **Renewable Energy:** Thailand has invested in renewable energy sources such as wind, solar, and hydropower. This diversification of the energy mix aims to reduce the emissions associated with power generation.
- 2) **Electric and Hybrid Vehicles:** The government has encouraged the use of electric and hybrid vehicles by providing incentives and infrastructure support, reducing the environmental impact of transportation.

### Urban Planning and Green Spaces

#### Efforts to improve air quality extend to urban planning and the creation of green spaces

- 1) **Urban Green Spaces:** The Thai government has initiated projects to develop urban green spaces, parks, and tree planting programs. These initiatives aim to increase green areas in cities, which can help mitigate PM2.5 pollution.
- 2) **Traffic Management:** Traffic congestion is a significant contributor to urban air pollution. The government has sought to improve traffic management and public transportation systems to reduce vehicle emissions in cities.

### Public Awareness and Health Education

Government initiatives also include public awareness campaigns and health education efforts to inform citizens about the dangers of PM2.5 pollution:

- 1) **Health Warnings:** The government disseminates health advisories and warnings during periods of high PM2.5 pollution. These warnings advise residents to take precautions, such as wearing masks and staying indoors.
- 2) **Educational Programs:** The government collaborates with healthcare organizations and educational institutions to educate the public on the health risks associated with PM2.5 pollution and the steps they can take to protect themselves.

### Challenges and Criticisms

While the government's initiatives are a crucial step towards combatting PM2.5 pollution, they have not been without challenges and criticisms:

- 1) **Enforcement:** The effective enforcement of emission standards and regulations can be a challenge, especially in regions with a high concentration of

industrial activity.

**Resource Allocation:** Some critics argue that more resources are needed to address the issue comprehensively. Budget constraints and resource allocation are matters of concern.

**2) International Collaboration:** Addressing PM2.5 pollution often requires international cooperation, as air quality issues transcend national boundaries. Critics emphasize the need for greater collaboration with neighboring countries.

## Conclusion

The research underscores the significance of public awareness and satisfaction in addressing PM2.5 pollution. An informed and engaged citizenry plays a pivotal role in shaping the trajectory of government initiatives. The results highlight both the successes and challenges in the battle against PM2.5 pollution. The high level of awareness regarding the health effects of PM2.5 pollution is a positive indicator of a population well-informed about the risks they face. However, this should not lead to complacency but should serve as a foundation for further education and advocacy. The diversity of opinions regarding government actions suggests that there is no one-size-fits-all solution to address PM2.5 pollution. Ongoing dialogue between the government and its citizens is crucial for continued progress. It is clear that public engagement, transparency, and responsiveness are vital for addressing the diverse needs and concerns of the population. The future prospects for managing PM2.5 pollution in Thailand depend not only on government actions but also on the active engagement and vigilance of the public.

## Acknowledgement

The author would like to express our sincere appreciation to the Faculty of Engineering at Bangkokthomburi University for their generous financial support, which was instrumental in the successful completion of this work.

## References

- Jin, H., Chen, X., Zhong, R. and Liu, M. 2022. Influence and prediction of PM2.5 through multiple environmental variables in China. *Science of The Total Environment*. 849: 157910. <https://doi.org/10.1016/j.scitotenv.2022.157910>
- Krittanawong, C., Qadeer, Y.K., Hayes, R.B., Wang, Z., Virani, S., Thurston, G.D. and Lavie, C.J. 2023. PM2.5 and Cardiovascular Health Risks. *Current Problems in Cardiology*. 48(6): 101670. <https://doi.org/10.1016/j.cpcardiol.2023.101670>
- Lu, D., Mao, W., Yang, D., Zhao, J. and Xu, J. 2018. Effects of land use and landscape pattern on PM2.5 in Yangtze River Delta, China. *Atmospheric Pollution Research*. 9(4): 707-713. <https://doi.org/10.1016/j.apr.2018.01.012>
- Xu, W., Yao, L., Fu, X., Wang, Y. and Sun, S. 2022. Response of PM2.5 variations to changing urbanization process in different climatic backgrounds of China. *Urban Climate*. 45: 101273. <https://doi.org/10.1016/j.uclim.2022.101273>
- Yamane, T. 1967. *Statistics, An Introductory Analysis*, 2nd Ed., New York: Harper and Row.
- Yousefi, R., Shaheen, A., Wang, F., Ge, Q., Wu, R., Lelieveld, J., Wang, J. and Su, X. 2023. Fine particulate matter (PM2.5) trends from land surface changes and air pollution policies in China during 1980–2020. *Journal of Environmental Management*. 326: 116847. <https://doi.org/10.1016/j.jenvman.2022.116847>