Review Article

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Policies and Practices for Environmental Health Services in Thailand: Surveillance, Prevention, and Management of Diseases and Health Threats Caused by $PM_{2.5}$

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Abstract

Thailand has recently faced a worsening $PM_{2.5}$ crisis, with the air quality fluctuating between safe and unsafe levels. Professionals trained in occupational and environmental health manage integrated environmental health services with geographic information systems to mitigate the health impacts of $PM_{2.5}$. Both active and passive measures are employed for the surveillance, prevention, and management of diseases and health threats caused by $PM_{2.5}$, thereby ensuring that communities maintain good health in safe environments. Although these practices align well with the environmental characteristics of a country, several challenges remain. This study examined the policies and practices of environmental health services in Thailand using policy analysis and surveillance systems review to gather information, focusing on safeguarding the health of the population affected by $PM_{2.5}$ pollution. This study could show Thailand's approach to establishing environmental health services, especially the collaboration between workplaces, communities, government agencies, and health service units, offers a valuable model for other large developing nations. However, its effectiveness is highly dependent on the participation of

all sectors of society and a system for monitoring and assessing the situation through continuous evaluation. Moreover, effective law enforcement and unwavering efforts to raise public health awareness in occupational and environmental health are essential for achieving sustainable success.

Keywords: Environmental health surveillance, $PM_{2.5}$, Policies, Practices, Thailand

Introduction

Air pollution is recognised as the largest environmental threat to human health owing to its significant contribution to the global disease burden. This is especially true for particulate matter (PM), including $PM_{2.5}$, a small particle with a diameter of less than 2.5 micrometres (μm).[1] PM with a diameter of no more than 2.5 μm is an environmental hazard threatening public health. The World Health Organisation (WHO) estimated that, in 2019, approximately 68% of premature deaths related to outdoor air pollution were caused by ischaemic heart disease and stroke, 14% by chronic obstructive pulmonary disease, 14% by acute lower respiratory infections, and 4% by lung cancers.[2] Exposure to PM, both short-term and long-term, leads to increased morbidity and mortality due to respiratory and cardiovascular disorders. In developing nations, outdoor PM is a significant factor that should not be overlooked when assessing indoor air quality. Indoor PM kills many people owing to biomass burning.[3] These issues may diminish, but air pollution from outdoors flows indoors; therefore, outdoor air is important for maintaining optimal indoor conditions as well.

Thailand faces significant air pollution challenges, with cities such as Bangkok and Chiang Mai frequently experiencing hazardous air quality levels. Once known for its relatively clean air, Chiang Mai overtook Bangkok in 2019 with $PM_{2.5}$ levels of 32.3 $\mu g/m^3$, pushing the Air Quality Index (AQI) rating to potentially hazardous levels. Thailand ranks 28th in the Swiss air quality technology company, IQAir's, 2019 World Air Quality Report, with a national $PM_{2.5}$ average of 24.3 $\mu g/m^3$—double the WHO's recommended exposure limit.[4] In Thailand, estimated deaths are 32,200 due to air pollution[5], of which 25,432 are specifically attributed to $PM_{2.5}$.[6] Regular fluctuations between safe and unsafe air quality levels have become a persistent issue, significantly affecting not only the general population but also vulnerable populations such as children, older adults, and those with pre-existing health conditions. Open agricultural burning, industrial activities, and vehicle exhaust fumes are major contributors to the air pollution crisis in Thailand, which is related to the following policies and practices.[7] In response to this growing health threat, the Royal Government of Thailand has implemented various measures,

including an official statement on air quality and a city-wide action plan.[7] The plan included stricter emission standards, the promotion of electric vehicles, and improved public transportation infrastructure to reduce traffic-related emissions. Furthermore, regulations were introduced to monitor and limit agricultural burning practices.[8] The Occupational and Environmental Diseases (EnvOcc) Division of the Ministry of Public Health (MoPH) plays a pivotal role in combating $PM_{2.5}$-related health threats. This Division focuses on conducting research, developing technology, and transferring knowledge to support surveillance, prevention, and management. Specific initiatives include toxicity, disease mechanisms, $PM_{2.5}$ measurement, risk assessment, risk communication, active and passive health surveillance, disease investigation, safety measures, and legal mechanisms.[7] Authorities have strengthened legal frameworks to hold industries accountable for emissions, and policymakers are promoting green technologies and sustainable practices, which are gaining momentum. International collaborations such as partnerships with the United Nations Environment Program and regional agreements with Association of Southeast Asian Nations (ASEAN) countries have also been initiated to address transboundary pollution. Public health officers, healthcare workers, occupational health professionals, government agencies, government organisations, the media, and the general public all play crucial roles in implementing and supporting air pollution mitigation strategies to protect against $PM_{2.5}$ exposure.[7,8]

This study examines the policies and practices of environmental health services in Thailand, focusing on the surveillance, prevention, and management of diseases and health threats caused by $PM_{2.5}$. By comprehensively addressing these challenges, Thailand aims to protect its population from the adverse effects of air pollution, enhance health safety, and improve the overall quality of life. Thailand's approach may provide valuable insights for developing nations facing similar air-quality issues.

Overview

Thailand, a Southeast Asian nation, has a mixed economy with major economic sectors including agriculture, manufacturing, tourism, service, and natural resources.[9] The capital city, Bangkok, or "Krung Thep," is home to a population of 71.60 million people. Thailand faces a growing environmental health crisis due to the persistent and pervasive problem of $PM_{2.5}$ pollution, which originates from various sources including vehicle emissions, industrial activities, biomass burning, agricultural residue combustion, and cross-border haze from neighboring countries. Due to its microscopic size, $PM_{2.5}$ can penetrate deep into the respiratory tract and

enter the bloodstream, causing both short-term and long-term health effects. $PM_{2.5}$ pollution in Thailand has far-reaching health consequences, affecting not only the lungs and heart but also brain function and mental well-being. The burden is not equally shared—children, outdoor workers, and the elderly bear a disproportionate share of the harm. The MoPH serves as Thailand's national health authority and is responsible for the formulation and implementation of health policies.[10] In the context of regional cooperation, Thailand is a member of the ASEAN and a signatory to the ASEAN Agreement on Transboundary Haze Pollution, established in 2002. This agreement aimed to mitigate toxic haze and prevent transboundary air pollution across Southeast Asia.[11] Thailand has enacted several laws to address air pollution and its impact on health and the environment, particularly in response to fine $PM_{2.5}$. Key legislative frameworks include the Enhancement and Conservation of National Environmental Quality Act Buddhist Era (B.E.) 2535 (1992), the Occupation Safety and Health Act (2011), and the Control of Occupational Diseases and Environmental Diseases Act B.E. 2562 (2019).[7] These measures reflect Thailand's commitment to mitigate the challenges posed by air pollution through a combination of policy implementation, regulatory control, and enhancement of international agreements. In addition, community organizations play a critical role as grassroots actors in the environmental health system by mobilizing local knowledge, promoting behavior change, and bridging communication between the public and government. Industries and private companies are key stakeholders, both as potential contributors to air pollution and as drivers of innovation and sustainability. An integrated environmental health system for managing $PM_{2.5}$ in Thailand must engage both community organizations and the private sector as active collaborators.

Environmental health surveillance system and health impact monitoring

In Thailand, environmental surveillance involves systematic and continuous collection, analysis, interpretation, and dissemination of information. The government employs geographic information systems to analyse the spatial distribution of pollutants, identify pollution hotspots, and determine air quality patterns across various locations. This process includes environmental monitoring, which focuses on the measurement and analysis of air pollutants, such as the AQI. Monitoring and disseminating information on air quality is essential for educating the public about air pollution and associated health risks.[12] $PM_{2.5}$ is considered the most harmful air pollutant to human health, particularly emphasised in such surveillance systems. As shown in Table 1, Thailand's AQI is divided into five levels, with each level represented by a distinct colour indicating the severity of health impacts. An AQI of 100 is equivalent to the general atmospheric

air quality standard. Values exceeding 100 indicate that pollutant concentrations surpass the standard, posing potential risks to public health.[13] The Air Quality Health Index (AQHI) has also been used in Thailand to communicate the health risks related to air pollution. The AQHI categorises air pollution levels into four categories[14] and provides a practical tool for policymakers to mitigate the acute health impacts of air pollution. Thailand employed multiple strategies to monitor and communicate its air pollution levels by leveraging social media and digital platforms. For example, the Air Quality and Noise Management Division of the Pollution Control Department has developed a dedicated website, "Air4Thai" (http://air4thai.pcd.go.th).[13] This platform analyses, processes, and presents the AQI levels obtained from nationwide air monitoring stations. To enhance accessibility, the "Air4Thai" smartphone application was introduced, offering free and real-time AQI updates to the public. Monitoring $PM_{2.5}$ levels using specialised tools is essential for comprehending localised air quality challenges and facilitating precise interventions.[7] Reliable data collection and thorough analysis are critical for informing evidence-based policies and implementing measures to mitigate dust pollution and associated health risks. Community Organizations

Table 1 Criteria of Thailand Air Quality Index and Air Quality Health Index and health recommendations

AQI	Color	AQI Meaning	AQHI	Risk level	Health recommendations
0 - 25		Excellent	1-3	Low	Everyone can live their life normally.
26 - 50		Satisfactory			**General public:** able to do outdoor activities normally **People who need special health care:** abnormal symptoms should be observed, such as frequent coughing, difficulty breathing, shortness of breath, wheezing, chest tightness, chest pain, palpitations, nausea, unusual fatigue, or dizziness.
51 - 100		Moderate	4-6	Moderate	**General public:** reduce the amount of time spent doing strenuous outdoor activities or exercises. **People who need special health care:** - Use personal protective equipment (PPE) such as $PM_{2.5}$ protective masks every time you go out. - Reduce the duration of activities or outdoor exercise that require a lot of energy. - If there are abnormal symptoms, consult a doctor immediately.
101 - 200		Unhealthy	7-10	High	**General public :** - Use PPE such as $PM_{2.5}$ protective masks every time you go out. - Limiting the amount of time spent doing strenuous outdoor activities or exercises. - Abnormal symptoms should be observed, such as coughing, difficulty breathing, or eye irritation. **People who need special health care :** - Use PPE such as $PM_{2.5}$ protective masks every time you go out. - Avoid activities or outdoor exercise - Follow your doctor's advice. If there are any abnormal symptoms, seek medical attention.

Table 1 Criteria of Thailand Air Quality Index and Air Quality Health Index and health recommendations (Cont.)

AQI	Color	AQI Meaning	AQHI	Risk level	Health recommendations
201 Above		Very Unhealthy	10+	Very high	**Everyone** - Should avoid outdoor activities. - Use PPE such as $PM_{2.5}$ protective masks every time you go out. - If you have any health symptoms, you should consult your doctor. - People with congenital diseases should be in a safe area from air pollution. Have the necessary medicines and equipment ready and strictly follow the doctor's advice.

Surveillance of health effects and disease investigation from $PM_{2.5}$

The ongoing, systematic process of collecting, analysing, and interpreting health data to track disease trends, spot possible outbreaks, and guide public health decision-making is known as the surveillance of health effects and disease investigation. This process plays the role of an early warning system for identifying and addressing new health concerns.

Active health surveillance involves identifying risk factors and health threats, thereby increasing the likelihood of detecting potential health effects. In Thailand, the guidelines for active health surveillance established by Thai public health officials include (1) risk assessment: assessing and actively collecting data on risk factors and identifying individuals who may be vulnerable to $PM_{2.5}$ exposure in affected areas, such as hospitals, schools, and nursing homes; and (2) surveillance of environmental data, which are utilised to monitor health impacts, develop intervention measures, and communicate risks to the affected population.[7,8] For example, authorities may announce temporary school closures or work-from-home policies when the air quality deteriorates.

Passive surveillance is used to report health impact monitoring data at regular intervals. Specific activities of passive surveillance such as (1) collection of routine health data: monitor

outpatient and inpatient records from hospitals and clinics using standardized ICD-10 codes related to respiratory, cardiovascular, and other $PM_{2.5}$-related diseases, (2) monitoring mortality records, (3) school and workplace health monitoring: collect absenteeism data from schools and workplaces and (4) seasonal trend analysis: conduct retrospective analysis of disease patterns concerning seasonal air pollution. Healthcare workers in public health facilities document patient data according to established protocols. This information is aggregated and forwarded to the relevant health authorities within the surveillance network.[7,8]

Disease investigation

The guidelines for investigating health incidents related to $PM_{2.5}$ exposure include event-based surveillance, verification of reported incidents, and coordination with the regional Office of Disease Prevention and Control. The investigation team verifies the event, prepares resources such as personnel, materials, and questionnaires, and defines case criteria to identify additional patients. A descriptive analysis of epidemiological data is used to explain exposure to $PM_{2.5}$, and cooperation across sectors is needed for effective control and prevention efforts. This includes guiding the affected individuals and at-risk populations. The final step involves health risk communication, which utilises accessible language and media to ensure that information is comprehensible to diverse audiences.[7,8]

Guidelines for environmental health services and public health care in response to $PM_{2.5}$ health threats

In areas affected by air pollution, the target population is classified into three groups: (1) the general population, (2) occupational groups, especially those who work outdoors, such as traffic police, and workers in industries involving dusty or dust-generating processes, and (3) vulnerable populations, which include individuals with heightened sensitivity to air pollution, including young children, pregnant women, older adults, persons with disabilities, and individuals with chronic diseases.[8] Environmental health services, operated by personnel with expertise in occupational and environmental health, focus on risk assessment, health surveillance, and disease diagnosis, treatment, and management. Additionally, they include the implementation of measures to support the surveillance, prevention, and management of $PM_{2.5}$ exposure, ensuring the promotion of good health in a safe environment (Table 2).

Table 2 Process of providing environmental health services in health service units of Thailand: Case of exposure to $PM_{2.5}$

	List of activities
1. Environmental health risk assessment	1.1 Risk considerations to predict health impacts caused by environmental pollution in the area. 1.2 Observe, evaluate data, follow up, and report $PM_{2.5}$ measurement results at each period that people in the area receive. 1.3 Use data to predict relationships with health effects so that health service units can appropriately plan to deal with the situation. In cases where it is expected that there will be many people affected by the $PM_{2.5}$ problem, health risk management will be undertaken such as arranging a place to accommodate patients. 1.4 Rik communication to people; publicize how to take care of yourself through various channels in the area such as social media, following information from reliable news sources such as the "Air4Thai" application, and actively conducting home visits for at-risk groups.
2. Environmental health surveillance	2.1 Collect data and analyze to find health threats or pollution that occur using the participation of people in the area such as making a body map (source of pollution, types, period, and health effects) and consider establishing an operation center. 2.2 Collect and analyze AQI results each day/period in the area. 2.3 Create a geo-social mapping to collect information on population, occupations, and various important places. 2.4 Create a family folder to collect data to know the treatment history, illness history, or referral history of people in the area. 2.5 Prepare a register to collect data each year to analyze and predict the situation in the coming years.
3. Diagnosis and treatment of environmental diseases	3.1 Take a history and physically examine the patient to see if they have any illnesses related to the $PM_{2.5}$ problem or not. For example, respiratory disease occurs when exposed to or inhaled pollutants during the $PM_{2.5}$ problem. 3.2 Evaluate the characteristics of outbreaks or disease occurrence/health effects from the environment in the community. Including the trend of problems/risks, the size of the problem, or how many people are affected. 3.3 Diagnose disease and find connections between disease or health effects with risk factors caused by environmental pollution, whether the disease is related to the occurrence of $PM_{2.5}$ problems or not. 3.4 Create a health database and diagnostic protocol such as sectors that accept biomarkers suitable for screening, various standard values, and guidelines for treating diseases from the environment.

Table 2 Process of providing environmental health services in health service units of Thailand: Case of exposure to $PM_{2.5}$ (Cont.)

	List of activities
4. Management of environmental health services	4.1 Prepare the necessary equipment and medical supplies for medical management and public health by setting up a system for referring patients to hospitals that have the potential or have a team of medical professionals to care for patients who have suffered from exposure to $PM_{2.5}$ 4.2 Preparing plans and emergency exercises to support and respond to public health emergencies arising from $PM_{2.5}$ problems such as evacuation plans for at-risk groups of people 4.3 Prepare the room to accommodate patients and the "clean room" especially for sensitive groups who need special care. 4.4 Environmental air pollution clinics should be opened in health service units to take care of people's health. Procedures for receiving services in the pollution clinic: (1) health screening, (2) health assessment and occupational and environmental assessment, (3) giving basic advice for $PM_{2.5}$ prevention, and (4) meeting a specialist doctor. 4.5 Coordinating organizations in all relevant sectors to closely monitor and manage the $PM_{2.5}$ problem situation. 4.6 Take strict legal measures by coordinating with relevant organizations to control $PM_{2.5}$ emissions from the source.
5. Support action in environmental health services	5.1 Public health organizations in the area create plans and projects or area policies to support solving problems such as creating a project to develop areas to prevent burning and detecting cars that emit black smoke. 5.2 Training and developing the potential of local occupational and environmental health practitioners to have knowledge and expertise in environmental health and health care from air pollution problems. 5.3 Training courses to make the advanced technology of pollution prevention and control (biomass reuse, agricultural waste reduction, electric-drive technologies) 5.4 Conduct research related to occupational health and environmental health or exposure to environmental pollution.

Discussion

Development of a health literacy awareness-building model and strict enforcement of the law by the government

The provision of environmental health services in Thailand, including surveillance, prevention, and control of diseases and health threats caused by $PM_{2.5}$, has received cooperation from all sectors of society. However, Thailand still regularly faces the problem of $PM_{2.5}$ due to problems in managing pollution sources, such as in urban areas, especially Bangkok, owing to the problem of diesel exhaust from vehicles. Meanwhile, in Chiang Mai province, where there is illegal open burning, such as the burning of agricultural waste, the building of health literacy and health awareness (behaviour change, protection skills, and prevention habits) of people in society is critical. Additionally, stakeholder coordination in occupational and environmental health management, and strict enforcement of the law by the government is essential to creating a sustainable system of environmental health services in Thailand.

Evaluation in the implementation: The Bangkok case–the Chiang Mai case

The MoPH presents a case of effective environmental health service implementation in Bangkok and Chiang Mai, attributed to its relatively ample resources, as they are two large provinces with multi-sectoral collaborative organisations that work together to solve the $PM_{2.5}$ problem. These two provinces have systematically managed environmental health services and implemented measures to respond to the $PM_{2.5}$ problem situation according to established guidelines. However, active monitoring and public relations focused on digital communication and alerts should take into account vulnerable groups including patients with asthma, older adults, bedridden individuals, people with disabilities, informal settlements (SLUM) in public health care coverage, and young children who may struggle to access alerts. Measures to provide medical and public health services through the establishment of pollution clinics should consider expanding the healthcare service network to reach remote rural communities, such as those in hilly regions, ensuring inclusive public healthcare coverage at all levels.

Strengths and limitations

The strength of Thailand's practices is found in its workplace, community, government, and health service units, along with the active and passive organisational framework managed by EnvOcc in the MoPH. However, the system's effectiveness relies on government policies, the involvement of all sectors of society, strict law enforcement, and continuous efforts to raise

health awareness among the population. If any of these elements fail, it jeopardizes the program's sustainability. Consequently, the ongoing promotion of occupational and environmental health awareness in all sectors is crucial. However, specific limitations in implementation may be found in rural and urban areas, where disparities across various aspects of life and policy enforcement barriers exist. An international comparison reveals that Thailand's practices for assessing, monitoring, preventing, and managing diseases and health threats caused by $PM_{2.5}$ are developing but still lag behind countries like Japan and South Korea, which have implemented more comprehensive air quality monitoring systems, stricter emission regulations, and integrated public health response strategies. In addition, barriers to inter-agency coordination include (1) fragmented authority where responsibilities are divided among multiple ministries and departments, often leading to overlapping or unclear mandates; (2) data silos: inconsistent data sharing between environmental and health agencies hampers timely health risk assessments and coordinated responses; (3) limited local capacity: local agencies often lack training and resources, which weakens the implementation of central government directives; (4) policy gaps and inconsistencies: different sectors (e.g., agriculture, transport, public health) may have conflicting priorities, and coordination mechanisms across sectors are still underdeveloped. While Thailand has a multi-level governance framework for addressing $PM_{2.5}$-related health threats, coordination challenges between central and local authorities, combined with capacity limitations and siloed data systems, continue to hinder effective integrated action. Strengthening cross-agency collaboration and empowering local governments are key areas for improvement.

Lesson learnt from Thailand

Thailand's approach to establishing environmental health services, especially the collaboration between workplaces, communities, government agencies, and health service units, offers a valuable model for other large developing nations. The integration of active and passive organisational structures has been instrumental in addressing environmental health challenges. For multidisciplinary collaborations to be effective, several factors must be considered: the population's health literacy level, compliance with relevant laws and policies, and the degree of stakeholder involvement. To replicate Thailand's models successfully, these strategies must be tailored to other countries' sociopolitical and cultural contexts.

Conclusion

Thailand implements environmental health service policies and practices through both active and passive operational systems. It involves setting up clear practices for assessing, monitoring, preventing, and managing diseases and health threats caused by $PM_{2.5}$, aiming to enhance health safety as reduced morbidity or improve AQI compliance, and improve the quality of life for affected individuals. However, its effectiveness is highly dependent on the participation of all sectors of society and a system for monitoring and assessing the situation through continuous evaluation. Moreover, effective law enforcement and unwavering efforts to raise public health awareness in occupational and environmental health are essential for achieving sustainable success.

Author Contributions

PK and AJ, study design; PK, AJ, AI, RMK, and NL, data gathering and discussion; PK, draft of manuscript; All authors have reviewed, edited, and approved the final manuscript.

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Conflicts of Interest

None declared.

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