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The Influence of Health Literacy on Preventive Behaviors among Village Health Volunteers in Smog-Affected Areas of Sukhothai Province, Thailand

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Abstract **Introduction:** Smog, especially fine particulate matter ($PM_{2.5}$), poses a major public health challenge in Thailand. Village health volunteers (VHVs) play a crucial role in promoting protective behaviors within affected communities. This study examines how health literacy (HL) influences preventive behaviors among VHVs in smog-affected areas of Sukhothai Province, Thailand. **Methods:** A cross-sectional survey involving 599 VHVs was conducted using a structured questionnaire to assess environmental health literacy (EHL) and preventive behaviors. HL levels were categorized as low (< 60%), moderate (60–79%), and high (≥ 80%) based on total percentage scores. Descriptive statistics and multiple linear regression were applied to identify predictors of preventive behaviors ($p < 0.05$). **Results:** The mean HL score was 84.24 (SD = 10.02) out of 110, indicating a moderate HL level (76.6%). Preventive behaviors were rated high (mean = 44.40, SD = 5.73). Regression analysis revealed that HL self-management ($\beta = 0.239$, $p < .001$), access to information ($\beta = 0.217$, $p < .001$), HL knowledge ($\beta = 0.097$, $p < .05$), and perceived smog severity ($\beta = 0.085$, $p < .05$) significantly predicted preventive behaviors, explaining 22.4% of the variance (adjusted $R^2 = 0.224$). **Conclusions:** HL, particularly in self-management and information access, significantly contributes to preventive behaviors among VHVs. Therefore, community-based education aimed at enhancing HL is recommended to mitigate health risks from air pollution.

Keywords Health Literacy, Preventive Behaviors, Village Health Volunteers (VHVs), $PM_{2.5}$, Smog Situation

1. Introduction

Air pollution is a major environmental and public health concern globally, with fine particulate matter ($PM_{2.5}$) identified as a leading contributor. According to the World Health Organization (WHO), over 90% of the global population is exposed to air pollution levels that exceed safe thresholds, contributing to approximately 7 million premature deaths annually [1]. $PM_{2.5}$ comprises particles with a diameter of 2.5 microns or smaller, primarily generated by vehicle emissions, industrial processes, agricultural burning, and wildfires [2]. These ultrafine particles can penetrate deep into the lungs and reach the alveoli, posing serious risks such as respiratory and cardiovascular diseases, as well as premature mortality [3,4]. Recognizing the severity of this issue, the WHO emphasized $PM_{2.5}$ as a global health hazard in 2016, calling for urgent national action [5]. Since then, there has been increasing advocacy for targeted health protection strategies to address pollution from wildfires and seasonal haze, which are major $PM_{2.5}$ sources in many regions [6]. In Southeast Asia, transboundary haze during the dry season, driven by agricultural burning and forest fires, exacerbates $PM_{2.5}$ pollution [7]. Northern Thailand is particularly vulnerable due to biomass burning, unfavorable meteorological conditions, and temperature inversions that trap pollutants near the ground [8]. Prolonged exposure to $PM_{2.5}$ in these areas has been linked to respiratory illness, reduced lung function, and increased hospital admissions [9]. Thus, understanding how communities perceive and respond to these environmental hazards is critical, especially in areas that experience recurring smog events. Public awareness, health literacy, and the adoption of protective behaviors are essential to mitigating health risks and strengthening community resilience [10]. In Thailand, trained village health volunteers (T-VHVs) play a crucial role in promoting basic healthcare, health education, and disease prevention—particularly in rural and underserved communities with limited access to formal healthcare systems. Their role becomes especially vital during environmental health emergencies such as smog episodes, where they act as frontline communicators and agents of behavioral change. Sukhothai Province, located in the lower northern region of Thailand, is considered a high-risk area for $PM_{2.5}$ exposure due to seasonal agricultural burning, wildfires, and transboundary haze from neighboring regions [11,12]. The province's rural nature and reliance on community-based health systems make it a relevant setting for examining the role of health literacy in shaping protective behaviors. During the haze season, average $PM_{2.5}$ concentrations reach approximately 23.1 μg/m³ [13,14], with frequent exceedances of the 24-hour standard of 50–60 μg/m³, particularly in February and March. On April 4, 2025, $PM_{2.5}$ levels reached 55 μg/m³ [15]. The establishment of a dedicated air quality monitoring station in 2023 has enabled more accurate tracking of $PM_{2.5}$ levels, which remained moderate to high throughout early 2025 [14]. This development underscores the urgent need to empower T-VHVs to disseminate accurate health information and promote protective behaviors in response to smog hazards. The health impacts of $PM_{2.5}$ exposure in Thailand have been well documented. Buya et al. [13] identified a strong association between elevated $PM_{2.5}$ levels and cardiorespiratory mortality, noting a 6% increase in deaths during high-pollution periods. Additional studies have confirmed the adverse effects of $PM_{2.5}$ on respiratory function, cardiovascular health, and overall morbidity [16]. Moreover, the risk of premature mortality has been shown to rise by approximately 5% when $PM_{2.5}$ concentrations exceed 37.5 μg/m³. Recent research utilizing environmental epidemiology and health risk assessment underscores the urgent need for effective air quality management, particularly in high-risk provinces such as Sukhothai [17].

This study examines the relationship between health literacy and preventive behaviors among T-VHVs in smog-affected areas of Sukhothai Province. The findings are expected to inform evidence-based policies and targeted interventions that strengthen the capacity of T-VHVs to mitigate air pollution–related health risks within their communities.

2. Materials and Methods

2.1. Study Design and Research Site

This study employed a cross-sectional research design.

2.2. Population and Sample

The target population for this study comprised VHVs registered in the Public Health Information System of the Bureau of Community Health Support as of 2020. The study focused on VHVs from nine districts in Sukhothai Province: Mueang Sukhothai, Kong Krailas, Khiri Mat, Si Samrong, Si Nakhon, Thung Saliam, Si Satchanalai, Sawankhalok, and Ban Dan Lan Hoi, totaling 12,835 individuals [18].

A sample of 599 VHVs was selected for this study. The required sample size was calculated using the n4Studies program developed by Wayne [19–21] based on the population means reported in previous research [22]. The formula used was designed to estimate a finite population mean. The initial sample size was calculated to be 565 participants. To account for potential data loss, the researcher increased the sample size by 5%, resulting in a final target sample of 599 participants. Inclusion criteria: Village health volunteers (VHVs) registered in Sukhothai Province, aged 20 years and above, with at least one year of service experience, residing in the selected districts for no less than one year, and able to provide informed consent. Exclusion criteria: VHVs who were inactive during data collection, had cognitive impairments, or declined to participate.

A cluster sampling approach was employed at the district level. Three districts were randomly selected to ensure manageability of field data collection while maintaining geographic diversity within the province. These districts, namely Si Satchanalai, Si Samrong, and Thung Saliam, were also chosen because they consistently reported elevated $PM_{2.5}$ levels during the smog season in prior years, based on secondary data from the Pollution Control Department. Within each district, two sub-districts were randomly chosen, followed by four villages per sub-district. From each village, 24–25 VHVs were selected through simple random sampling using a non-replacement lottery method.

2.3. Research Instrument

The study utilized a structured questionnaire, developed by the researcher, to explore essential variables across four sections:

Section 1: Personal Factors. This section comprised eight items related to demographic and background information, including gender, age, education, occupation, income, years of experience as a VHV, duration of residence in the community, and underlying health conditions.

Section 2: Perceived Impact of Haze on Health. This section consisted of 12 Likert-scale items developed by the researcher to assess participants' perceptions and experiences regarding the health effects of haze exposure.

Section 3: Health Literacy Assessment for Self-Protection in Haze Conditions. This section included 30 items developed by the researcher based on Nutbeam's conceptual framework [23] and guidelines from the Bureau of Health Education, Department of Health Service Support, Ministry of Public Health [24]. The total possible score was 110 points, distributed across the following components: 1) Knowledge and Understanding of Haze Conditions – 10 binary-choice items ("yes"/"no") assessing essential knowledge about healthcare and disease prevention in haze conditions. A score of 1 was assigned for each correct response, and 0 for each incorrect one. The maximum possible score pertaining to this component was 10 points; 2) Access to Health Information and Services; 3) Comprehension of Health Information and Services; 4) Evaluation of Health Information and Services; and 5) Self-Management – These components were measured using 20 Likert-scale items, each rated on a 5-point scale. The total possible score was 100 points.

Section 4: Self-Protective Behaviors. This section comprised 12 Likert-scale items developed to assess the frequency of protective behaviors practiced in response to haze conditions.

Instrument Validity and Reliability: Content validity was evaluated by three experts in public health, yielding an item-objective congruence (IOC) range of 0.80–1.00. A pilot study with 30 VHVs was conducted to assess reliability, resulting in a Cronbach's alpha of 0.87, indicating high internal consistency.

2.4. Data Collection Procedure

Upon obtaining ethical approval from the Human Ethics Committee of the University of Phayao, all participants were thoroughly informed of the study's objectives, data collection procedures, and measures to ensure confidentiality. Prior to participation, written informed consent was obtained from each individual. Data collection was conducted using a self-administered questionnaire, with an estimated completion time of 30 to 40 minutes.

2.5. Statistical Analysis

Data analysis was conducted using a statistical software program. Descriptive statistics, namely frequency, percentage, mean, and standard deviation, were utilized to summarize demographic information and the participants' levels of health literacy concerning the haze situation. To assess the predictive power of the independent variables on both preventive behaviors and health literacy, multiple linear regression analysis was employed. All relevant statistical assumptions, including the normality of the metavariables, were examined and found to be satisfied. A significance level of $\alpha = 0.05$ was applied to all statistical tests.

2.6. Ethical Approval

The Research Ethics Committee of the University of Phayao, Thailand, approved the study (Approval No. HREC-UP-HSST 1.2/068/67).

3. Results

3.1. Descriptive Statistics of VHVs' Demographic Characteristics

A total of 599 participants were included in the study. The average age was 53.68 years (SD = 9.68), with an age range of 20 to 60 years. The majority of participants were female (n = 521, 87.0%), and male participants accounted for only 13.0% (n = 78). Most participants were married (n = 451, 75.3%), with smaller proportions being widowed (10.7%), single (9.2%), or divorced/separated (4.8%). In terms of educational attainment, the largest proportion of the participants had completed primary education (53.1%). This was followed by those who held a high school diploma, vocational certificate, or had completed non-formal education (21.0%) and those who had completed junior high school (18.2%) (as shown in Table 1).

Table 1. Demographic characteristics of VHVs (n = 599)

Demographic characteristics	Frequency	%
Gender		
Male	78	13.0
Female	521	87.0
Age (years) ($\bar{X}$ = 53.68, SD = 9.68, Min = 20.0, Max = 60.0)		
20 – 40	58	9.7
41 – 59	382	63.8
≥ 60	159	26.5
Marital Status		
Single	55	9.2
Marriage	451	75.3
Widowed	64	10.7
Divorced / Separated	29	4.8
Education Level		
No degree obtained	2	.3
Primary school	318	53.1
Junior High School	109	18.2
High School Diploma / Vocational Certificate / Non-Formal Education	126	21.0
Diploma / Higher Vocational Certificate	22	3.7
Bachelor	19	3.2
Higher than Bachelor	3	.5
Occupational status		
Government Officer / State Enterprise Employee	3	.5
Farmer	445	74.3
Daily Wage Worker / Laborer	82	13.7
Self-Employed / Business Owner	37	6.2
Unemployed	32	5.3
Family Income/Month (Baht) ($\bar{X}$ = 6,716.94, SD = 6,277.89, Min = 900.00, Max = 65,000.00)		
< 2,500	111	18.5
2,500 – 10,000	417	69.6
> 10,000	71	11.9
Experience of Being a Village Health Volunteer (years) ($\bar{X}$ = 15.47, SD = 9.39, Min = 1.00, Max = 47.00)		
< 10	219	36.6
10 – 20	219	36.6
> 20	161	26.8
Length of Residency in the Community (Years) ($\bar{X}$ = 45.05, SD = 15.15, Min = 1.00, Max = 75.00)		
< 35	152	25.4
35 – 55	279	46.6
> 55	168	28.0
History of Chronic Diseases (Multiple Responses Allowed)		
Absent	336	56.1
Present	263	43.9
Hypertension	224	68.6
Diabetes Mellitus	83	23.2
Cerebrovascular disease	6	1.7
Asthma	11	3.1
Heart disease	12	3.4

3.2. Level of Smog Situation, Health Literacy, and Preventive Behaviors

As shown in Table 2, the participants perceived the smog situation as severe, with a mean score of 46.84 (SD = 7.45). The overall health literacy (HL) score was high (mean = 84.24, SD = 10.02), and all five components of HL were rated at a high level: Knowledge (mean = 7.87, SD = 1.14), Access to Information and Services (mean = 19.17, SD = 2.84), Understanding of Information and Services (mean = 18.98, SD = 2.72), Evaluation of Information and Services (mean = 18.51, SD = 2.92), and Self-Management (mean = 19.70, SD = 2.84). Preventive behaviors among VHVs were also found to be at a high level, with a mean score of 44.40 (SD = 5.73), indicating strong engagement in health-protective practices related to smog exposure (as shown in Table 2).

3.3. Predictors of Preventive Behaviors

Multiple regression analysis revealed that four variables significantly predicted preventive behaviors (adjusted $R^2 = 0.224$, $F = 44.197$, $p < .001$). Self-management was the strongest predictor ($\beta = 0.239$, $p < .001$), followed by access to health information ($\beta = 0.217$, $p < .001$), and health literacy knowledge ($\beta = 0.097$, $p < .05$). Perceived severity of the smog situation was minor but statistically significant ($\beta = 0.085$, $p < .05$). All variance inflation factors (VIFs) were below 2, indicating no multicollinearity among the predictors. These results highlight the importance of health literacy, especially self-management and information access, as key drivers of effective preventive behaviors among VHVs in smog-affected areas (as shown in Table 3).

Table 2. Mean, Standard Deviation, and Level of Smog Situation, Health Literacy, and Preventive Behaviors of the Participants (n = 599)

Variables	Min	Max	$\bar{X}$	SD	Level
Smog Situation	22.00	60.00	46.84	7.45	Severe
Health Literacy (Overall)	48.00	108.00	84.24	10.02	High
Knowledge	2.00	10.00	7.87	1.14	High
Access to Information and Services	8.00	25.00	19.17	2.84	High
Understanding of Information and Services	11.00	25.00	18.98	2.72	High
Evaluation of Information and Services	9.00	25.00	18.51	2.92	High
Self-Management	12.00	25.00	19.70	2.84	High
Preventive Behaviors	24.00	58.00	44.40	5.73	High

Table 3. Multiple Regression Analysis of Factors Influencing Preventive Behaviors of VHVs

Predictors	B	SE	β	t	Sig.	95%CI		VIF
						LB	UB	
(Constant)	19.595	2.035	-	9.630	< .001**	15.598	23.591	-
Smog Situation	0.065	0.032	0.085	2.063	< .05*	0.003	0.128	1.315
HL Knowledge	0.486	0.191	0.097	2.548	< .05*	0.111	0.860	1.113
HL Access to Information and Services	0.439	0.093	0.217	4.740	< .001**	0.257	0.621	1.623
HL Self-Management	0.482	0.093	0.239	5.163	< .001**	0.299	0.666	1.655

$R = .479$, $R^2 = .229$, Adjusted $R^2 = .224$, $F = 44.197$, $P < .001$

$^{**}p < .001$, $^{*}p < .05$

4. Discussion

This study confirms that health literacy is a significant determinant of preventive behavior among VHVs in regions affected by $PM_{2.5}$. Participants scored highly in self-management, access to information, and environmental health knowledge and had strong perceptions of smog severity. The regression model indicated that self-management ($\beta = 0.239$, $p < .001$), access to information ($\beta = 0.217$, $p < .001$), knowledge ($\beta = 0.097$, $p < .05$), and perceived smog severity ($\beta = 0.085$, $p < .05$) together explained 22.4% of the variance in preventive behaviors (adjusted $R^2 = 0.224$, $F = 44.197$, $p < .001$).

The finding that health literacy knowledge significantly predicts preventive behaviors ($\beta = 0.097$, $p < .05$) suggests that VHVs with a greater understanding of environmental health risks, especially those related to $PM_{2.5}$ are more likely to engage in proactive protective behaviors. This aligns with Lichtveld et al. [25], who highlighted environmental health literacy (EHL) as a key factor shaping individuals' ability to take protective action against environmental hazards. It also supports the EHL framework, which posits that knowledge acquisition is foundational to behavioral change [26].

Moreover, the results align with existing literature indicating a positive relationship between environmental health literacy and protective responses to pollution exposure. For example, Raufman et al. [27] reported that higher levels of EHL were associated with a reduction in household air pollution–related symptoms in Kenya, reflecting how awareness and understanding of pollution risks can drive protective behaviors. Pansakun et al. [28] similarly reported a link between EHL and $PM_{2.5}$ preventive behaviors among VHVs in northern Thailand. Likewise, Boonkerd and Surakarn [29] demonstrated that EHL-focused interventions enhanced both knowledge and preventive actions among schoolchildren, while Sripha [30] emphasized the role of EHL in strengthening preventive behaviors among VHVs in rural northeastern Thailand. These findings suggest that EHL interventions are effective across diverse populations and contexts. These international findings reinforce the present study's conclusion that perceived risk and environmental literacy are strong motivators for protective action. These findings underscore the value of accessible, practical, and culturally sensitive educational tools for community health workers. While knowledge alone may not guarantee behavioral change, it serves as a crucial foundation for decision-making and motivates community-level engagement. This supports previous studies suggesting that repeated pollution events enhance public concern and participation in environmental health education efforts [30,31], and that perceived risk plays a key role in driving motivation and information-seeking behavior [32].

Although the effect size of health literacy knowledge was modest ($\beta = 0.097$), its statistical significance confirms that basic knowledge of $PM_{2.5}$ and its health impacts is crucial. It lays the groundwork for behavioral change by fostering risk awareness and encouraging action [26]. However, without access to reliable information and the self-management skills to act, knowledge may not translate into consistent protective behavior.

Furthermore, our findings support previous research from Lampang Province, which indicated that limited self-monitoring among VHVs was associated with lower engagement in smog-related preventive behaviors [33]. The present study extends this understanding by quantifying the role of perceived severity within a broader health literacy framework.

These findings underscore the importance of integrating environmental risk communication and self-management training into VHV development programs. Future studies should explore the sustainability of interventions and their applicability in other high-risk regions.

The strong association between health literacy self-management and preventive behavior indicates that VHVs who can regulate their actions, make informed decisions, and maintain health-promoting routines are more likely to take consistent, effective steps to reduce exposure to $PM_{2.5}$. This aligns with previous studies indicating that individuals with higher self-regulatory capacity tend to adopt consistent protective measures, such as limiting outdoor activities and promoting awareness in their communities [27,28].

Therefore, interventions targeting VHVs should not limit themselves to simple information dissemination. A comprehensive health literacy strategy that enhances self-regulation skills and information access is essential. Tailored education programs augmented by mobile-based air quality alerts and community workshops may encourage sustainable protective behaviors among frontline health volunteers operating in smog-prone regions. This study has certain limitations. First, it relied on self-reported data, which may be subject to response bias. Second, the sample was limited to VHVs in Sukhothai Province, which may limit the generalizability of the findings to other regions. Future studies should thus include a broader range of participants and consider longitudinal or qualitative approaches to gain deeper insights. Further research is recommended to explore how sociocultural factors and community dynamics influence preventive behaviors in different contexts. Additionally, intervention studies are needed to assess the effectiveness of tailored EHL programs in improving health outcomes in smog-affected areas.

Several limitations should be acknowledged in this study. First, the use of self-reported data may have introduced response bias. Second, the cross-sectional nature of the research restricts the ability to draw causal inferences between health literacy and preventive behaviors. Third, the study sample was confined to three districts within Sukhothai Province, potentially limiting the generalizability of the results to areas with differing social and healthcare system contexts. Future research should thus include VHVs from multiple regions and diverse settings to improve generalizability and consider longitudinal designs to better understand causality and track behavior change over time. In addition, qualitative research is recommended to capture deeper insights into community perceptions, cultural influences, and barriers to behavior change.

5. Conclusions

This study underscores the critical role of health literacy, particularly in self-management, information access, and environmental knowledge, in shaping preventive behaviors among VHVs in $PM_{2.5}$-affected regions. These factors explained 22.4% of the behavioral variance, emphasizing the influence of both cognitive and perceptual dimensions on health decision-making. The findings provide empirical support for integrating environmental health literacy (EHL) into public health policy and standard VHV training curricula, with a focus on risk communication, behavioral self-regulation, and localized air quality monitoring. Community workshops and mobile-based platforms may further enhance these efforts. For future research, longitudinal studies involving VHVs across diverse regions of Thailand are recommended. Such studies would improve generalizability, explore causal pathways, and better reflect contextual variations in community health structures and VHV roles.

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Conflict of Interest

All authors declare no conflicts of interest.

REFERENCES

[1] World Health Organization, "WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide," World Health Organization, 2021. [Online]. Available: https://www.who.int/publications/i/item/9789240034228. [Accessed: Mar. 12, 2025].

[2] J. Lelieveld, K. Klingmüller, A. Pozzer, R. T. Burnett, A. Haines, and V. Ramanathan, "Effects of fossil fuel and total anthropogenic emission removal on public health and climate," *Proc. Natl. Acad. Sci. U.S.A.*, vol. 117, no. 15, pp. 7192–7197, 2020. DOI: 10.1073/pnas.1819989116.

[3] A. J. Cohen, M. Brauer, R. Burnett, H. R. Anderson, J. Frostad, K. Estep, et al., "Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Disease Study 2015," *Lancet*, vol. 389, no. 10082, pp. 1907–1917, 2017. DOI: 10.1016/S0140-6736(17)30505-6.

[4] World Health Organization, "Health effects of particulate matter," World Health Organization, 2013. [Online]. Available: https://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf (accessed Mar. 15, 2025).

[5] World Health Organization, "Public health and environment/Air pollution," World Health Organization, 2016. [Online]. Available: https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/ambient-air-pollution (accessed Mar. 15, 2025).

[6] S. Vardoulakis, B. B. Jalaludin, G. G. Morgan, I. C. Hanigan, and F. H. Johnston, "Bushfire smoke: urgent need for a national health protection strategy," *The Medical Journal of Australia*, vol. 212, no. 8, p. 349, 2020. DOI: 10.5694/mja2.50511.

[7] N. T. Kim Oanh, W. Thiansathit, T. C. Bond, R. Subramanian, E. Winijkul, and I. Paw-armart, "Characterization of emissions from open burning of biomass in Southeast Asia," *Environmental Pollution*, vol. 268, p. 115828, 2021. DOI: 10.1016/j.envpol.2020.115828.

[8] P. Vongruang, S. Pimonsree, and N. Ponamornklang, "Climate influence on PM2.5 pollution in Northern Thailand," *Atmospheric Pollution Research*, vol. 12, no. 2, pp. 388–398, 2021. DOI: 10.1016/j.apr.2020.12.012.

[9] C. Liu, R. Chen, F. Sera, A. M. Vicedo-Cabrera, Y. Guo, S. Tong, et al., "Ambient particulate air pollution and daily mortality in 652 cities," *The New England Journal of Medicine*, vol. 381, no. 8, pp. 705–715, 2019. DOI: 10.1056/NEJMoa1817364.

[10] D. Nutbeam, "Health literacy as a public health goal: a systematic review," *Health Promotion International*, vol. 15, no. 3, pp. 259–267, 2000. DOI: 10.1093/heapro/15.3.259.

[11] Regional Environment Office 3 Phitsanulok, "Performance report on the forest fire and haze mitigation project in Tak, Phitsanulok, Phetchabun, Sukhothai, and Uttaradit provinces for the fiscal year 2021," Pollution Control Department, Ministry of Natural Resources and Environment, 2021. [Online]. Available: https://epo03.pcd.go.th/th/information/more/220 (accessed Mar. 15, 2025). (In Thai).

[12] H. J. Bambrick, A. G. Capon, G. B. Barnett, R. M. Beaty, and A. J. Burton, "Climate change and health in the urban environment: adaptation opportunities in Australian cities," *Asia-Pacific Journal of Public Health*, vol. 23, no. 2 Suppl,

pp. 675–679, 2011. DOI: 10.1177/1010539510391774.

[13] S. Buya, H. Gokon, V. N. Huynh, H. C. Dam, and C. H. Lin, "Spatiotemporal association between monthly PM2.5 levels and cardiorespiratory mortality in Thailand (2015–2019)," *International Journal of Environmental Health Research*, 2025. DOI: 10.1080/09603123.2025.1000000.

[14] W. Thongsame, D. K. Henze, R. Kumar, M. C. Barth, and G. Pfister, "Evaluation of WRF-Chem PM2.5 simulations in Thailand with different anthropogenic and biomass-burning emissions," *Atmospheric Environment: X*, vol. 14, p. 100282, 2024. DOI: 10.1016/j.aeaoa.2024.100282.

[15] J. Kaewrat and R. Janta, "Effect of COVID-19 prevention measures on air quality in Thailand," *Aerosol and Air Quality Research*, vol. 20, no. 6, p. 1344, 2020. DOI: 10.4209/aaqr.2020.06.0344.

[16] PCD Air4Thai, "Daily Air Quality Report – April 4, 2025," Pollution Control Department, Thailand, 2025. [Online]. Available: https://www.air4thai.pcd.go.th. [Accessed: Mar. 15, 2025].

[17] K. Ueda, S. Sujaritpong, H. Praekunatham, H. Lin, and A. Morita, "Health impacts from PM2.5 exposure using environmental epidemiology and health risk assessment: a review," *Applied Environmental Research*, vol. 45, no. 2, pp. 23–41, 2023. DOI: 10.35762/aer.2023.45.2.2.

[18] Y. Yaebkai and P. Wongsawat, "Factors affecting performance of village health volunteers in Sukhothai, Thailand," *Journal of Public Health and Development*, vol. 20, no. 1, pp. 120–131, 2022. DOI: 10.55131/jphd/2022/200110.

[19] W. D. Wayne, *Biostatistics: A foundation of analysis in the health sciences*, 6th ed., New York: John Wiley & Sons, 1995.

[20] C. Ngamjarus and P. Pattanittum, "n4Studies Plus: Application for sample size calculation in health science research," [Mobile application], Version 1.4, App Store, 2024. [Online]. Available: https://apps.apple.com.

[21] C. Ngamjarus, *Sample size calculation for health science researc*, 1st ed., Khon Kaen University Printing House, 2021.

[22] W. W. Daniel, *Biostatistics: A foundation of analysis in the health sciences*, 6th ed., John Wiley & Sons, 1995, pp. 177–178.

[23] D. Nutbeam, "Health promotion glossary," *Health Promotion International*, vol. 13, pp. 349–364, 1998.

[24] Health Education Division, Department of Health Service Support, Ministry of Public Health, "Health literacy toolkit in health care services," Health Education Division, 2019. [Online]. Available: https://anyflip.com/mrrga/kcrv/basic. [Accessed: Apr. 5, 2025].

[25] M. Y. Lichtveld, H. H. Covert, M. Sherman, A. Shankar, J. K. Wickliffe, and C. S. Alcala, "Advancing environmental health literacy: validated scales of general environmental health and environmental media-specific knowledge, attitudes and behaviors," *International Journal of Environmental Research and Public Health*, vol. 16, no. 21, p. 4157, 2019. DOI: 10.3390/ijerph16214157.

[26] S. Finn and L. O'Fallon, "The emergence of environmental health literacy—from its roots to its future potential," *Environmental Health Perspectives*, vol. 125, no. 4, pp. 495–501, 2017. DOI: 10.1289/ehp.1409337.

[27] J. Raufman, D. Blansky, D. W. Lounsbury, E. W. Mwangi, Q. Lan, J. Olloquequi, and H. D. Hosgood III, "Environmental health literacy and household air pollution-associated symptoms in Kenya: a cross-sectional study," *Environmental Health*, vol. 19, no. 1, p. 89, 2020. DOI: 10.1186/s12940-020-00643-5.

[28] N. Pansakun, W. Naksen, W. Boonchieng, P. Ong-Artborirak, and T. Prapamontol, "Environmental health literacy regarding fine particulate matter and related factors among village health volunteers in Upper Northern Thailand," *Journal of Preventive Medicine and Public Health*, vol. 57, no. 2, pp. 138–147, 2024. DOI: 10.3961/jpmph.23.434.

[29] L. Boonkerd and A. Surakarn, "The effects of environmental health literacy enhancement program for promoting preventive behavior from PM2.5 among Grade 6 students at a private school in Samutprakarn Province," *Journal of Behavioral Science for Development*, vol. 16, no. 2, pp. 92–117, 2024. [Online]. Available: https://so02.tci-thaijo.org/index.php/JBSD/article/view/271321.

[30] W. Sripha, "Developing environmental health literacy to tackle the problem of microscopic particles (PM2.5) in the village health volunteers, Sophisai district," *Songklanagarind Journal of Nursing*, vol. 14, no. 1, pp. 29–39, 2021. (In Thai)

[31] Y. Zhao, Y. Sheng, J. Zhou, H. Wang, M. M. Chilufya, X. Liu, et al., "Influencing factors of residents' environmental health literacy in Shaanxi province, China: a cross-sectional study," *BMC Public Health*, vol. 22, no. 1, p. 114, 2022. DOI: 10.1186/s12889-022-12561-x.

[32] W. H. Hou, Y. C. Huang, C. Y. Lu, I. C. Chen, P. C. Lee, M. Y. Lin, et al., "A national survey of ambient air pollution health literacy among adult residents of Taiwan," *BMC Public Health*, vol. 21, no. 1, p. 1604, 2021. DOI: 10.1186/s12889-021-11658-z.

[33] Y. L. Weng, C. C. Liang, C. C. Tseng, S. Y. Lee, and G. L. Yeh, "A survey of PM2.5 preventive behavioral intention and related factors among community elderly in Northern Taiwan," *Medicine (Baltimore)*, vol. 100, no. 29, p. e26675, 2021. DOI: 10.1097/MD.0000000000026675.