Research Article

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Knowledge, Attitudes, and Practices towards Protecting School-Age Children from Particulate Matter in Samut Prakan, Thailand

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Abstract

This cross-sectional study evaluated caregivers' practices and identified factors associated with protecting school-age children from exposure to fine particulate matter in the Pak Nam Subdistrict of Samut Prakan Province, Thailand. Data on the sociodemographic characteristics, knowledge, attitudes, and practices of 389 caregivers of students in Grades 1 to 6 from seven elementary schools were collected using a structured questionnaire. Univariate logistic regression was then used to analyze the associations between these variables. The results showed that approximately half of the respondents had good knowledge and positive attitudes, but only 22.8% had good protective practices. These respondents need to improve their practices in checking ambient air quality, minimizing children's exposure, and selecting appropriate masks. Factors associated with good practices included being aged 40-49 years (p=0.010), educational level (p=0.004), and various occupations, such as governmental or private employees (p= 0.028), business owners (p= 0.004), and retirees or housewives (p= 0.004). Furthermore, respondents with good knowledge (OR: 1.98, 95% CI= 1.18-3.34, p= 0.006) and positive attitudes (OR: 1.89, 95% CI= 1.14-3.14, p= 0.009) were more likely to exhibit better practices. These findings, along with policy actions, highlight the need for targeted interventions to promote behavioral adaptations in specific demographic groups.

Keywords: Caregiver, Knowledge, Attitudes, and Practices (KAP), Particulate matter, Children, School

What was Known

- School-age children are particularly vulnerable to exposure to particulate matter (PM). Numerous epidemiological studies worldwide have demonstrated significant links between PM exposure and adverse health effects in this age group, including acute respiratory infections, reduced lung function, and decreased intelligence.
- Pak Nam, Samut Prakan, is home to fifteen elementary schools and is one of the most polluted areas in Thailand. A previous study found a significant association between increased outpatient department (OPD) visits for respiratory diseases in children aged 6 to 14 and rising PM10 levels in the province.
- Currently, there is no available data on how caregivers in the area safeguard their children from exposure to PM.

What's New and Next

- Only twenty percent of caregivers employed effective protective practices against PM exposure. Most depended on their children wearing masks instead of minimizing exposure by keeping them indoors.
- Factors significantly associated with good practices included age, education level, occupation, knowledge, and attitudes.
- Based on these findings, schools, along with the Ministry of Public Health and the Ministry of Education, should develop a strategic plan to protect children's health in the community.

Introduction

Although substantial amounts of disease burden are attributed to particulate matter (PM), up to 93% of children under 15 years old worldwide are exposed to fine particulate matter that exceeds World Health Organization guidelines[1]. This has particularly drawn attention to the PM-related health effects on children, given that their respiratory rates are faster than those of adults and that their immune systems at birth and lungs are still under development[2]. Typically, children spend much time outdoors, where their breathing zones are closer to the ground—an area where PM from motor vehicles originates. Additionally, their physical activities often increase respiration rates[2]. These factors contribute to making school-age children one of the most vulnerable groups. Supported by numerous epidemiological studies, links between PM exposure levels and health effects on this age group—such as acute respiratory infections[3,4,5,6], reduced lung function[7], and reduced intelligence[8,9]—have been revealed.

Like many countries, including India, China, and Bangladesh[10,11], one of the major environmental challenges in Thailand is particulate air pollution. While biomass burning is the primary source of pollution in the northern region, vehicular and industrial emissions are the main contributors to PM pollution in the Bangkok Metropolitan Region (the Metropolis of Bangkok and five adjacent provinces: Nakhon Pathom, Pathum Thani, Nonthaburi, Samut Prakan, and Samut Sakhon)[12,13]. One particular area of concern is the Pak Nam Subdistrict in Samut Prakan Province. Despite its small size of just 9.30 km^2, it is home to 3 piers, 46 registered factories, and heavy traffic, making it one of the most polluted areas in Thailand[14-17]. In 2023, the 24-hour average $PM_{2.5}$ concentration reached the maximum value of 156 $\mu g/m^3$ and exceeded the national standard of 37.5 $\mu g/m^3$ for 75 out of 181 days during the peak season[17]. A previous study also found significant associations between outpatient department visits (OPD) for respiratory diseases among children aged 6 to 14 and increased PM_{10} in Samut Prakan Province[18]. Although controlling or removing pollution sources is the best management practice, balancing a good environment and economic growth may slow down the process. While awaiting effective and sustainable solutions, almost ten thousand children in 15 elementary schools located in Pak Nam are still facing recurrently severe PM episodes. Surprisingly, there is no information on how caregivers in the area protect their children from fine PM. To address this gap, the Knowledge-Attitudes-Practices (KAP) framework—a common approach in health science surveys—was used to understand caregivers' knowledge, beliefs, and actions to protect their children's health in the community. Acknowledging the role of socioeconomic factors and

varying levels of knowledge and attitudes in shaping protective behaviors, this research aimed to explore the factors influencing practices for safeguarding school-age children from exposure to fine PM in the Pak Nam Subdistrict of Samut Prakan Province, Thailand. These findings offered comprehensive information that could be used to create a specific public health strategic plan for the area.

Materials and Methods

Sampling Method

This research was conducted from February to April 2021. The study focused on the caregivers of 9,016 students in fifteen primary schools in Pak Nam Subdistrict, Thailand. According to Cochran's formula, a sample size of 369 was estimated. A school was randomly selected, followed by one representative classroom from each grade level (grades 1–6) within that school. This random selection process was repeated until the desired number of caregivers was achieved. A paper-based questionnaire was distributed to caregivers through the schools. In total, 389 caregivers aged 18 and older, who were able to read and write in Thai and willing to participate in the project, were selected from seven schools—three private and four public—out of the 15 primary schools in the area.

Research Instrument

A self-administered questionnaire was pretested with 30 participants from a non-target elementary school in the same area. Based on the assessment of three experts, the item objective congruence (IOC) index was 0.91. The overall Cronbach's alpha coefficient was 0.71. The questionnaire consisted of two parts: general information and KAP.

The general information section covered the demographic characteristics of the caregivers and their children, including the caregivers' sex, age, educational attainment, occupation, and caregiver-child relationship. For the children, the demographic information included the type of school, class level, sex, and health status.

PM-based knowledge was assessed using 20 statements related to PM situations and sources in Samut Prakan Province, children's susceptibility to and health impacts from fine PM, the air quality warning system, and children's protective measures. The response options for each statement were "Yes," "No," and "Do not know/Not sure." A correct answer was scored 1, while an incorrect or "do not know/not sure" answer was scored 0.

Attitudes were assessed through 10 statements addressing concerns and perceptions regarding fine PM and protective actions for children. The scores for positive attitude statements ranged from 5 (strongly agree), 4 (agree), 3 (uncertain), 2 (disagree), and 1 (strongly disagree), while a reverse scale was used for negative attitude statements.

Practices were evaluated using 12 statements, including checking ambient air quality, avoiding PM exposure, selecting personal protective equipment (PPE), educating children about potential health effects, and monitoring children's health during high PM episodes.The scores for positive statements, except for face mask selection for children, ranged from 5 (always), 4 (often), 3 (sometimes), 2 (seldom), and 1 (never), while negative statements were given inversely. Scores for face mask selection were as follows: 5 (N95 or N95-equivalent respirators), 4 (surgical mask), 3 (cloth mask), 2 (sponge mask), and 1 (not wearing). Ten additional questions, including reasons for not performing specific practices, were included to investigate barriers to practice.

For each part of KAP, a summative score in the last tertile indicated a "good level," while scores below that indicated a need for improvement.

Data Analysis

Data were analyzed using the R program version 4.2.3. The mean, standard deviation, and frequency were used to describe caregivers' characteristics and their KAP. A univariate logistic regression was performed to quantify the associations between the independent and dependent variables. Therefore, the sample sizes for each analysis may differ from the total number reported in the descriptive statistics.

Results

Sociodemographic Characteristics

The demographic item responses included data from 382 to 389 respondents, except for caregivers' age (n = 349) and children's education level (n = 375). Among the respondents, 82.0 percent identified as parents. The mean (SD) age was 42 (9.9), with the majority being between 18-49 years old (81.4%). Most respondents were female (75.1%) and had achieved a diploma below the bachelor's level (67.3%). Various occupations were observed, including government/private employees (38.7%), daily hire employees (21.2%), business owners (19.4%), and retirees or housewives (20.7%). As for children, approximately sixty percent studied in public schools and were in the upper elementary grades. The number of female students was slightly

higher than that of male students, and most caregivers reported that their children were healthy (83.2%).

KAP and factors associated with caregivers' practices

In general, 49.5% (n = 189/382) of the respondents displayed good knowledge (95% CI: 44.5–54.5), while slightly fewer, at 40.1% (n = 155/387), exhibited positive attitudes (95% CI: 35.3–45.0). However, only 22.8% (n =88/386) demonstrated good protective practices (95% CI: 18.9–27.2). The mean (SD) scores for knowledge, attitudes, and practices were 13.4 (2.9), 38.7 (4.2), and 38.9 (6.9), respectively.

Based on the caregivers' knowledge presented in Table 1, the majority of respondents demonstrated a good understanding of the sources and situations of fine particulate matter (PM) in Samut Prakan (K1-K2), as well as its short-term health effects (K10-K12). Correspondingly, approximately 85-96% of caregivers recognized the importance of checking ambient air quality (A10) and expressed concerns about children's susceptibility to PM (A1), the health effects of PM exposure on children (A2), and children's mask-wearing behaviors (A6) (Table 2). In addition, approximately 70% of the respondents were aware of the high levels of PM present in congested traffic (A5) and expressed confidence in the significance of air purifiers (A9).

In terms of practices (Table 3), while 98.2% of children regularly wore face masks, only 25.6% consistently wore properly fitted masks (P9). The three most commonly chosen types of face masks were surgical masks (74.3%), N95 or N-95 equivalent respirators (16.2%), and cloth masks (4%). To minimize exposure during high PM episodes, approximately half of the caregivers regularly closed doors and windows (46.6%), prohibited children from playing outdoors (40.4%), refrained from taking their children outside (50.0%), and avoided areas with heavy traffic (41.2%). It is noticeable that only 20% of caregivers consistently checked the Air Quality Index (AQI), and an even smaller percentage, 12.4%, regularly used air purifiers.

Table 1 Knowledge of caregivers in relation to fine particulate matter

Statement	Number (%)	
	Correct	Incorrect
K1: The main sources of fine PM in Samut Prakan are industries and road traffic.	336(87.5)	48(12.5)
K2: Fine PM levels in Samut Prakan have reached unhealthy levels for the past two years.	300(78.1)	84(21.9)
K3: Samut Prakan ranks among the three most polluted provinces in Thailand.	238(62.0)	146(38.0)
K4: Fine PM in Samut Prakan exceeds the national ambient standard during the winter seasons.	239(62.2)	145(37.8)
K5: Fine PM cannot be seen with the naked eye.	331(86.2)	53(13.8)
K6: Fine PM can penetrate deeply into pulmonary alveoli and the vascular system.	296(77.3)	87(22.7)
K7: Fine PM often increases during stable meteorology conditions.	234(61.1)	149(38.9)
K8: Indoor levels of fine PM increase as outdoor levels of fine PM increase.	203(52.9)	181(47.1)
K9: Fine PM from fuel combustion, such as car exhaust, contains carcinogens.	324(84.4)	60(15.6)
K10: Fine PM has the potential to cause respiratory diseases in children.	359(93.5)	25(6.5)
K11: Fine PM has the potential to cause nasal, ocular, and skin symptoms in children.	357(93.0)	27(7.0)
K12: Fine PM can exacerbate asthma symptoms.	305(79.4)	79(20.6)
K13: Fine PM may possibly affect children's intelligence quotient (IQ).	138(36.0)	245(64.0)
K14: Long-term exposure to fine PM is likely to increase the risk of heart diseases in children.	138(35.9)	246(64.1)
K15: Long-term exposure to fine PM is likely to cause premature death.	182(47.4)	202(52.6)
K16: Healthy children are not affected by fine PM exposure.	319(83.1)	65(16.9)
K17: Surgical masks can provide protection for children against exposure to fine PM.	188(49.0)	196(51.0)
K18: The surgical mask has the highest efficiency, followed by the N95 respirator and then the cloth mask.	134(34.9)	250(65.1)
K19: The fit of the face mask is dependent on the dimensions of the child's face.	287(74.7)	97(25.3)
K20: Color-coded AQI or AQI values specifically represent the $PM_{2.5}$ situation.	214(55.7)	170(44.3)

Table 2 Caregivers' attitudes towards protecting children from fine particulate matter

Statement	Number (%)		
	Agree[a]	Uncertain	Disagree[b]
A1: My child is at risk due to high concentrations of fine PM in Samut Prakan.	332(85.8)	50(12.9)	5(1.3)
A2: I am worried about the health impacts of fine PM exposure on my child.	372(96.1)	12(3.1)	3(0.8)
A3: There is no need to change my child's daily routine during times of high $PM_{2.5}$ episodes.	209(54.0)	72(18.6)	106(27.4)
A4: It is safer for my child to stay indoors during high PM episodes.	217(56.1)	122(31.5)	48(12.4)
A5: I believe that the levels of fine PM in congested traffic areas differ from those in other areas.	285(73.6)	87(22.5)	15(3.9)
A6: I feel worried when my child does not wear a face mask during episodes of high PM.	369(95.4)	8(2.0)	10(2.6)
A7: A surgical mask is enough to keep my child protected from exposure to fine PM.	122(31.5)	141(36.4)	124(32.1)
A8: I believe that an adult-sized face mask can be used to protect my child from fine PM.	159(41.0)	123(31.8)	105(27.2)
A9: An air purifier is important equipment for removing fine indoor PM.	283(73.1)	86(22.2)	18(4.7)
A10: In my view, the fine PM monitoring report (AQI) is highly useful.	359(92.8)	14(3.6)	14(3.6)

[a] *The response categories of "strongly agree" and "agree" are combined.*

[b] *The response categories of "strongly disagree" and "disagree" are combined.*

Table 3 Caregivers' practices towards protecting children during high levels of fine particulate matter episodes

Statements	Number (%)		
	Regularly[a]	Sometimes	Rarely[b]
P1: Watch AQI	77(20.0)	48(12.4)	261(67.6)
P2: Use an air purifier	48(12.4)	1(0.3)	337(87.3)
P3: Close doors/windows	180(46.6)	77(20)	129(33.4)
P4: Prohibit my child from playing outside	156(40.4)	43(11.2)	187(48.4)
P5: Bring my child along when going out	193(50.0)	146(37.8)	47(12.2)
P6: Avoid heavy traffic	159 (41.2)	96 (24.9)	131 (33.9)
P7: Educate my child about the health effects of PM exposure	237(61.4)	99(25.6)	50(13.0)
P8: Observe my child's health status	271(70.2)	80(20.7)	35(9.1)
P9: Ensure that the selected mask fits my child's face properly	99(25.6)	240(62.2)	47(12.2)
P10: Remind my child to wear a face mask before going out	323(83.7)	30(7.8)	33(8.5)
P11: Remind my child to wear a face mask properly when it slips off his/her face	342(88.6)	28(7.3)	16(4.1)

[a] *The response categories of "always" and "often" are combined.*

[b] *The response categories of "seldom" and "never" are combined.*

Table 4 shows that caregivers aged 40–49 years had a higher likelihood of practicing good protective measures compared to those aged 18–39 years (OR: 2.05; 95% CI = 1.14–3.73, p = 0.010). Caregivers with a bachelor's degree or higher were twice as likely to have good practices compared to those with a lower degree (OR: 2.04; 95% CI = 1.21–3.43, p = 0.004). Furthermore, individuals employed on a monthly payroll—specifically governmental or private employees (OR: 2.38; 95% CI = 1.04–5.98, p = 0.028), business owners (OR: 3.38; 95% CI = 1.35–9.00, p = 0.004), and retirees/housewives (OR: 3.29; 95% CI = 1.32–8.67, p = 0.004)—were more likely to exhibit better practices than daily hire employees. In terms of knowledge and attitudes, respondents with higher scores were more likely to have better practices (OR: 1.98; 95% CI = 1.18–3.34, p = 0.006 for knowledge and OR: 1.89; 95% CI = 1.14–3.14, p = 0.009 for attitudes).

Table 4 Factors associated with caregivers' practices toward protecting children from fine particulate matter episodes

Variables	Good n(%)	Need for improvement n(%)	OR (95%CI)	*p*
Type of school				
Public	48(19.8)	194(80.2)	1	
Private	40(27.8)	104(72.2)	1.55 (0.93 ,2.59)	0.072
Gender				
Male	15(15.6)	81(84.4)	1	
Female	73(25.2)	217(74.8)	1.82 (0.96, 3.61)	0.053
Age				
18-39	25(18.7)	109(81.3)	1	
40-49	48(32.0)	102(68.0)	2.05(1.14, 3.73)	**0.010**
≥50	13(20.0)	52(80.0)	1.09(0.47 ,2.42)	0.821
Caregiver-child relationship				
Parent	76(24.1)	239(75.9)	1	
Relative	12(17.4)	57(82.6)	0.66 (0.31,1.33)	0.228
Caregivers' educational level				
Less than a Bachelor's degree	48(18.5)	211(81.5)	1	
Bachelor's degree or higher	40(31.7)	86(68.3)	2.04 (1.21,3.43)	**0.004**
Occupation				
Daily hire employee	9(11.1)	72(88.9)	1	
Government/Private employees	34(23.0)	114(77.0)	2.38 (1.04, 5.98)	**0.028**
Business owner	22(29.7)	52(70.3)	3.38 (1.35, 9.00)	**0.004**
Retiree or housewife	23(29.1)	56(70.9)	3.29 (1.32, 8.67)	**0.004**
Children's class level				
Lower class grades	35(23.0)	117(77.0)	1	
Upper class grades	50(22.4)	173(77.6)	0.97(0.58, 1.63)	0.891
Children's gender				
Male	32(19.2)	135(80.8)	1	
Female	55(25.6)	160(74.4)	1.45(0.86, 2.46)	0.138
Children's health status				
Healthy	68(21.3)	251(78.7)	1	
Unhealthy	20(31.2)	44(68.8)	1.68 (0.87, 3.13)	0.085

Table 4 Factors associated with caregivers' practices toward protecting children from fine particulate matter episodes (Cont.)

Variables	Good n(%)	Need for improvement n(%)	OR (95%CI)	*p*
Knowledge level				
Need for improvement	33(17.3)	158(82.7)	1	
Good	55(29.3)	133(70.7)	1.98(1.18, 3.34)	**0.006**
Attitude level				
Need for improvement	42(18.3)	188(81.7)	1	
Good	46(29.7)	109(70.3)	1.89(1.14, 3.14)	**0.009**

The bold text indicates statistical significance.

Discussion

Our findings revealed that only 22% of respondents exhibited good practices for protecting against fine particulate matter, despite having relatively high levels of knowledge and positive attitudes. This trend has been noted in various groups, including medical students and caregivers of unhealthy children aged 1-12 years in Colombia[19] and China[20], respectively. To tackle these issues effectively, it is crucial to clarify the specific problems and understand the relevant knowledge, attitudes, and barriers that impede good practices. This approach can help identify root causes and develop targeted strategies for improvement.

In our study, we identified three practices—checking air quality reports, minimizing exposure, and selecting appropriate face masks—that require enhancement. Considering the connections between relevant knowledge and attitude questions related to each practice, it was clear that most caregivers expressed significant concern for their children's health and felt anxious when their children did not wear face masks during periods of high PM levels. This concern reflects the caregivers' understanding of the sources, situations, and health impacts of fine PM, similar to parents in a rural area of Beijing where air pollution sources were also located near their homes[21]. As a result, 98.2% of caregivers in the Pak Nam subdistrict reported that their children regularly wore face masks. Based on our data collection, the respondents selected surgical masks for their children; they were unable to assess the masks' efficiency, and only one-quarter of the children used properly fitted face masks. These findings suggest that there may be a false sense of security associated with mask-wearing in the area. Although surgical masks are inexpensive, comfortable, and widely available, it is important to understand that surgical masks

reduce PM exposures by approximately 20% on average[22]. Additionally, children are unlikely to wear masks properly or keep them on their faces for extended periods[23]. Therefore, one suggested approach to minimize exposure is to stay indoors, as many studies have shown that this dramatically reduces $PM_{2.5}$ exposure, especially when outdoor air pollution is elevated[24]. However, only 12–50 percent of the caregivers in Pak Nam took these actions and supportive measures due to various obstacles. For example, some caregivers found it difficult to consistently close doors and windows during high PM episodes due to discomfort. Despite being aware of high ambient PM concentrations, caregivers often allowed their children to play outside for physiological and psychological relaxation. Concerning traffic avoidance, some still used the same congested routes primarily because of the hustle and bustle of city life. They also believed that the car cabin provided a safe space with minimal particulate exposure, which may be true if two important factors—accurate ventilation mode and high-efficiency cabin air filters—are properly deployed and maintained[25-28].

Among the aforementioned practices, a few were notably poor. Only 12 percent of caregivers owned and consistently used air purifiers, despite the fact that the vast majority recognized their benefits. One possible explanation for this could be the costs associated with purchasing and operating them[24]. Similarly, only 20 percent of respondents regularly checked the Air Quality Index (AQI) application. Overall, the practices of caregivers in the Pak Nam subdistrict contrasted with the behavioral intentions of parents in Beijing, who paid relatively equal attention to wearing face masks, staying indoors, and checking the AQI[21].Various results have been explored in different community contexts. For instance, only 0.5 percent of residents in Dhaka, Bangladesh, were aware of the AQI[29], highlighting the need for education on this topic. In Ningbo, China, the primary concern was the selection of face masks[30]. In our case, nearly 70 percent of caregivers were unaware of the AQI application, and among those who were aware, most found it difficult to use. The majority preferred receiving air quality data through pop-up social media notifications or TV broadcasts, as these were easier to access. However, this preference may increase the likelihood of missing warning messages about air pollution since the program schedule in Thailand is unpredictable and depends on administrative interests.

To promote the adoption of better practices among caregivers, we believed that providing information on the daily AQI could play a crucial role. This was because most respondents in the community already had a solid understanding of the fine PM situation and its

adverse health effects, and they expressed considerable concern for their children's health, as mentioned earlier. Therefore, we anticipated that being alert to air quality warnings would lead caregivers to prioritize their children's health over personal comfort and convenience. This increased vigilance would likely promote good practices, such as closing doors and windows, temporarily relocating to cleaner indoor air shelters, carefully planning children's outdoor activities, and seeking alternative routes or planning trips in advance, particularly during rush hours. A successful example of this was observed among sportspeople in Malaysia who canceled outdoor training sessions based on the severity of air quality indices[31]. In situations where exposure is unavoidable, it is recommended to use respirators specifically designed for children, such as KF94 or KN95 masks[32].

The question arises of how to effectively convey the message in this area. An online survey conducted in Thailand revealed that residents of Chiang Mai and Bangkok who perceived a higher health risk from $PM_{2.5}$ were more likely to engage in self-monitoring of air pollution[33]. However, this data may not fully represent certain populations, such as individuals with limited digital literacy and those with a low socioeconomic status. In our study group, self-monitoring of air pollution remained low, despite strong concerns for children's health. As previously noted, pop-up media has proven to be a popular communication tool. We propose utilizing the Line application for school-home communications, as it successfully engages caregivers of schoolchildren. To maintain consistency, the responsible authority, such as the Ministry of Education, may require schools to monitor air quality and provide brief notifications about pollution alerts and best practices during the peak season. For those unfamiliar with AQI, caregivers must be introduced to the application to ensure sustainable access to information in the future. Although the AQI has been accessible to Thais for several years, many still do not use it. In our view, this is because the environmental organization has focused primarily on monitoring and reporting information, while the health and education systems, which work closely with communities, have not actively engaged in activities related to air pollution protection. Therefore, a key to overcoming this problem may be concrete collaboration among the Ministry of Natural Resources and Environment, the Ministry of Public Health, the Ministry of Education, and local government. In addition, certain features of the AQI application should be improved. For instance, a warning symbol for high PM days, such as a superscript number, should be displayed on the application icon, allowing users to recognize the need to check air quality without having to access the application daily. Instead of using general terms like

" exposure avoidances," specific actions should be provided, such as " closing windows" and "turning on the air cleaner."

Considering the effects of sociodemographic variables on practices, caregivers who are older, have higher levels of education, and hold more stable jobs are likely to demonstrate better practices. These findings align with several studies in environmental health. For instance, research conducted in Bangladesh revealed that effective protective practices against ambient fine particulate matter were significantly linked to age, education level, and occupation[29]. A study by Shabani Isenaj et al. (2024) indicated that parents' overall practical behavior scores related to air pollution improved with higher educational attainment[34]. Liu et al. (2018) also demonstrated that increased parental education and income, along with better resource accessibility in urban areas of Beijing, influenced behavioral intentions regarding $PM_{2.5}$[21]. Furthermore, in Shanghai, the two most significant factors affecting caregivers' practices for children aged 1 to 12 years were education level and income, suggesting that individuals with higher education and greater average annual household incomes were more concerned about air quality[20]. Unfortunately, this study could not explore the relationship between income and practices due to a lack of data. Despite this limitation, our research indicated that caregivers with stable jobs tended to exhibit better practices compared to those who were daily hires, implying a possible link to income. Regarding the links between K-P and A-P, our results revealed that caregivers with greater knowledge and more concerned attitudes are likely to engage in improved practices. By understanding the relationships between these variables, we can develop effective interventions using localized data to improve practices. Targeted education—such as highlighting the long-term threats of fine PM and emphasizing the importance of keeping children indoors instead of relying solely on masks—should be prioritized to further strengthen awareness of perceived risks. This education should be accompanied by coaching and step-by-step training on reading and interpreting the Air Quality Index (AQI), minimizing PM exposure, and selecting suitable masks for children to encourage behavioral adaptation. Such initiatives can be integrated into school events, such as home meetings, to engage families directly. Meanwhile, policy actions aimed at improving the AQI reporting system and leveraging popular social media platforms, as previously mentioned, could also support these efforts.

For the study's limitations, we used a self-administered questionnaire to collect data on caregivers' practices instead of behavioral observation. To minimize biases that may arise from caregivers' self-evaluations, we employed various questioning techniques. For instance, instead

of using broad time frames (e.g., always, sometimes, seldom), we asked caregivers to specify the exact number of times they performed certain practices (e.g., every day, once a week). We then assessed the consistency of their practices using the same criteria (e.g., everyday activities were deemed regular actions). Additionally, the mask-wearing behaviors observed in this research were likely influenced by the COVID-19 pandemic, even though our data were collected shortly before the situation intensified in the study area. Nonetheless, there remained a possibility of overreporting, particularly concerning children's mask-wearing. To mitigate this potential bias, we explicitly framed questions that could have been affected by the pandemic, including those related to mask use, with the phrase relevant to PM exposure (e.g., during periods of fine PM episodes). This approach was intended to remind respondents that the context of the questions was separate from the pandemic.

Conclusion

It was clear that most caretakers prioritized ensuring that children wore masks rather than reducing their children's exposure. These findings can help responsible authorities understand the need for educational programs and formulate appropriate strategies. Given the existing resources, our primary recommendation is to utilize effective communication channels, such as homeschool networks, to disseminate alerts about daily air quality. Knowledge gaps and clear guidance on protective measures should be incorporated into the program for school events. This approach requires top-down policy support from educational authorities, coupled with a bottom-up effort to ensure that school leaders, particularly principals, recognize the impact of fine PM on children's health. Concurrently, the Ministry of Natural Resources and Environment should invest in risk communication, particularly regarding the air quality warning system and specific measures to promote best practices. Further research into the longitudinal monitoring of behavior change should also be pursued.

Ethical Approval Statement

The Ethical Review Committee for Human Research at Mahidol University granted ethical approval for this study on February 5, 2021 (Protocol No. 183/2563).

Author Contributions

P. K. and T. S. developed the study concept and methodology. P. K. carried out the investigation and performed the data analysis along with N.A. and A.P. T.S. supervised the study.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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