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ORIGINAL RESEARCH

Effectiveness of a Knowledge-Oriented Educational Intervention on Air Pollution Health Protection Among Primary School Students: A Pilot Pre-Post Study

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Background: Air pollution remains a major global public health challenge, and reducing its harmful health effects is urgent, particularly for children. The objective of this study was to evaluate the preliminary effectiveness of knowledge-oriented education on the knowledge, attitudes, and practices (KAP) of air pollution health protection (APHP) in primary school students.

Methods: We conducted a single-arm pre-post intervention study by enrolling 635 primary school students. A two-month knowledge-oriented education intervention was performed through health lectures, educational videos, and the distribution of educational materials. A structured questionnaire was used to assess the KAP of air pollution before and after the intervention.

Results: After the intervention, the capability of air pollution protection was significantly improved as suggested by the significantly increased total score of KAP from 83.90±8.75 to 92.28±4.75, as well as its components including knowledge (20.45±3.13 vs 23.20 ±2.16), attitudes (31.60±4.03 vs 34.54±2.09), and practices (31.84±4.89 vs 34.52±2.67) (all $P<0.05$). These increments seemed to be more apparent in students who did not live with their parents and those whose mothers had a higher education level.

Conclusion: Our pilot study found that KAP of APHP was significantly improved by knowledge-oriented education in primary school students and provided preliminary evidence for its potential effectiveness in the improvement of APHP. A well-designed randomized trial is warranted to demonstrate this effectiveness.

Keywords: knowledge-oriented education, air pollution, primary school students, health protection

Introduction

Air pollution has become a major global public health concern, posing a substantial health risk.[1–4] According to air quality data from cities worldwide in 2022, air pollution affected 83% of high-income cities and 99% of low-income cities whose air quality exceeded the recommended level by the World Health Organization (WHO).[5] Almost all of the global population (99%) is exposed to air pollution.[6] The average life expectancy in Europe continues to shorten by about 2.2 years and an estimated 4.2 million people worldwide die each year as a result of air pollution.[7,8] Therefore, air pollution health protection (APHP) is important for people's health but how to effectively promote this critical skill is still controversial.

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Background

Environmental education is considered a critical tool for countering air pollution and can promote intrinsic motivation for APHP.[9] Researchers believe that developing ecologically friendly motivations during childhood may have lifelong effects, due to their plasticity in behaviors.[10] Knowledge, attitude, and practice (KAP) theory posits that the accumulation of knowledge serves as the foundation for attitude change, which in turn facilitates behavioral transformation.[11] This theory is frequently applied in questionnaire design to assess the current status of KAP among specific populations in a given region, and to develop intervention measures based on the results to promote the formation of positive behaviors.[12] Several studies have emphasized the role of knowledge-based education, such as special lectures, distribution of promotional brochures, and broadcasting health education-related materials, in enhancing public and secondary school students' KAP toward APHP.[13–16] However, whether knowledge-oriented education would improve KAP regarding the environmental health protection for primary school students is unclear, because the respiratory systems of primary school students are particularly susceptible to air pollution.[17,18] Effective educational interventions can help primary school students establish correct health awareness and cultivate good health behavior habits, which will have a long-term positive impact on their health. Therefore, we conducted a pilot study by comparing KAP regarding APHP before and after a knowledge-oriented education intervention in 635 students from two primary schools in Suzhou Industrial Park. Suzhou Industrial Park stands as one of the earliest new town projects in China to employ urban design tools for guiding its development.[19] The annual average concentrations of PM2.5 across various functional zones within the industrial park ranged from 25.9 to 27.5 μg/m^3, significantly outperforming China's Grade I ambient air quality standard (10μg/m^3), yet still five times the annual average concentration limit recommended by the World Health Organization (5μg/m^3).[20,21] This pilot study will provide preliminary data for the design of a randomized clinical trial in the future to effectively improve the APHP.

Methods

Study Participants and Design

The study design and selection of participants are illustrated in Figure 1. In brief, two primary schools that had not previously benefited from knowledge-oriented education interventions were selected in the industrial park, Suzhou, China. Considering the comprehension ability, the students from the third to the fifth grades at the two selected schools were chosen for inclusion. Using a class-based cluster random sampling approach, 666 students from the 15 randomly selected classes were invited to participate in our study. After the collection of written informed consent from their parents, a two-month duration, knowledge-oriented education intervention was implemented from December 2023 to January 2024. The KAP of APHP was assessed repeatedly before and after the intervention. This study was approved by the Ethics Committee of Soochow University and conducted in accordance with the Declaration of Helsinki. Finally, 635 students who completed both the pre- and post-intervention assessments were included in the current study.

Knowledge-Oriented Education Interventions

Obtaining strong knowledge and skills about the air environment through learning in schools is essential to consider the wider implications of pollution.[22] Due to the pronounced relationship between environmental knowledge and behavior,[23] students need to actively receive knowledge, which can gradually develop healthy attitudes and practices, thereby improving APHP.

In the present study, a two-month knowledge-oriented education intervention was performed through health lectures, educational videos, and the distribution of educational materials (Figure 2).[24] Specific interventions involved the following:

1. Cognitive intervention (week 1): In the first week, we focused on cognitive intervention. This was implemented through face-to-face communication with students in the school. A 45-minute air pollution-themed lecture was held for all classes and delivered by one lecturer, who was responsible for presenting the core knowledge about air pollution. Two to three teaching assistants were present during each lecture. Their roles included managing the classroom order, ensuring students' active participation, and answering students' simple questions on the spot to enhance the learning effect.

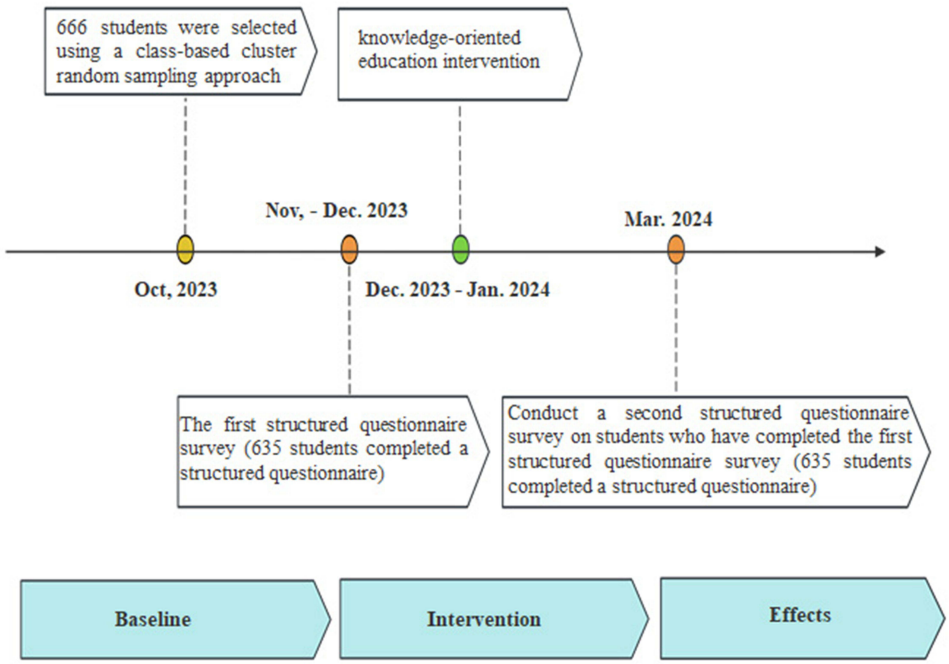

Figure 1 A flow chart illustrating the study design and selection of study participants. A total of 666 students from 15 randomly selected classes were invited to participate in our study. After a two-month intervention, 635 students completed and provided pre- and post-intervention assessments of knowledge, attitudes, and practices of air pollution health protection.

2. Media-based intervention (throughout the two months): The vivid 10-minute short videos related to knowledge on health protection against air pollution and broadcast in the activity room cycle exhibition. The topics of videos were updated weekly.
3. Environmental intervention (throughout the two months): The use of school promotional bulletin boards, permanent posters and display boards, and brochures, to create an environment for popularizing the science of health protection in heavily polluted weather. The design principles of the promotional materials were concise, vivid, scientific, and language popularization, in line with the cognitive and receptive level of elementary school students.

Assessment of KAP of Air Pollution Health Protection

The outcome of the intervention was the KAP of APHP, which was assessed using a structured questionnaire administered by trained staff before and after the intervention. The design of the survey questionnaire is based on the "Survey Questionnaire on the Health Protection Effectiveness of Air Pollution in Primary School Students" compiled by the Environmental and Health-Related Product Safety Institute of the China Center for Disease Control and Prevention.[25] Parents or guardians assisted students in completing the basic information of the survey subjects, while the survey subjects independently completed the awareness of air pollution protection knowledge. The pre-and post-intervention questionnaire surveys were carried out in November 2023 and March 2024, respectively.

The answers to each question in the questionnaire were scored quantitatively. The full score of KAP was 27, 36, and 37, respectively. The total score was the sum of the scores of these three components, with the full score of 100.

Statistical Analysis

The baseline characteristics of study participants were presented in means and percentages, as appropriate. The average level of KAP of air pollution (assessed by the total score of the questionnaire and each component) before and after the intervention was compared using the paired t-test. To uncover potential modifications, stratification analysis was additionally conducted in subgroups based on gender, grade, living with parents (Yes/No), and parents' educational

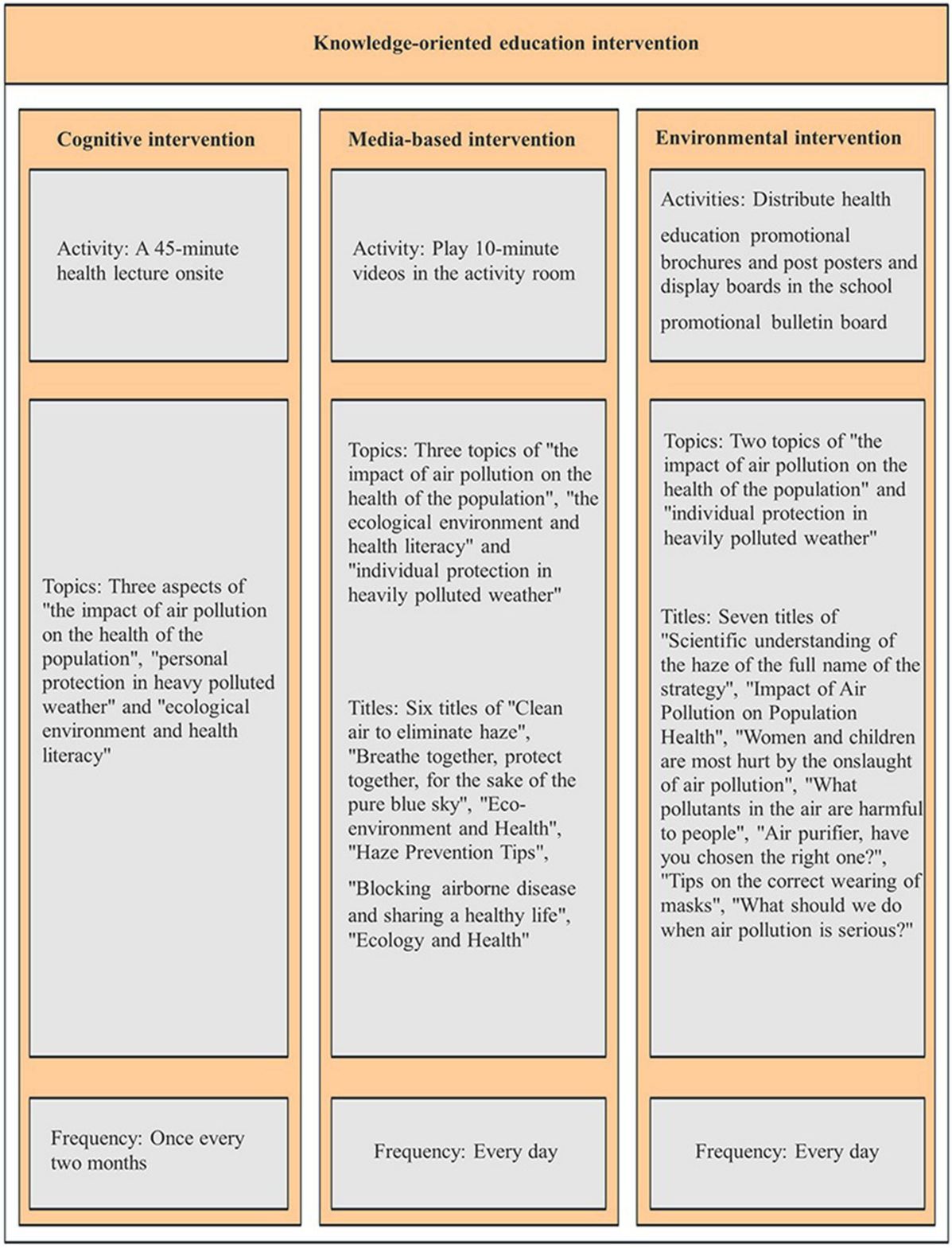

Figure 2 Knowledge-oriented education intervention.

level (High School or below vs Bachelor vs Master or above). All statistical analyses were performed using R 4.3.2, and a 2-tailed P value less than 0.05 was considered statistically significant.

Results

Baseline Characteristics of Study Participants

A total of 635 students including 331 males and 304 females completed the pre-and post-intervention questionnaire surveys, with a follow-up rate of 95%. The general information of the participants is presented in Table 1. The average age of the students was 9±1years. Of them, 30.39%, 22.68%, and 46.93% were from the third, fourth, and fifth grades, respectively. The majority of students, 616 (97.01%), lived with their parents, most of whom had a college or higher education, with 467 (73.54%) and 132 (20.79%) respectively.

Effect of Knowledge-Oriented Education on KAP of Air Pollution Health Protection

The mean total score before and after the intervention was 83.90±8.75 and 92.28±4.75, respectively, with a significant difference (Table 2, $P < 0.01$). Of these students, 93.54% experienced an increase in total score. There was no decrease in the total score of the participants after the intervention (Figure 3). Similar results were observed for each component

Table 1 Baseline Characteristics of Study Participants

Characteristics	Mean/Percentage	95% CI*
Age, mean ± SD	9.53±1.01	9.45–9.60
Sex, n (%)		
Males	331(52.13)	48.16–56.07%
Females	304(47.87)	43.93–51.84%
Grade, n (%)		
Third	193(30.39)	26.84–34.14%
Fourth	144(22.68)	19.48–26.14%
Fifth	298(46.93)	42.99–50.90%
Live with parents, n (%)		
Yes	616(97.01)	95.37–98.19%
No	19(2.99)	1.81–4.63%
Father's educational level, n (%)		
High School or below	36(5.67)	4.00–7.76%
Bachelor	467(73.54)	69.93–76.94%
Master or above	132(20.79)	17.69–24.15%
Mother's educational level, n (%)		
High School or below	56(8.82)	6.73–11.70%
Bachelor	482(75.91)	72.38–79.18%
Master or above	97(15.27)	12.57–18.31%

Note: *The 95% confidence interval of the corresponding means or percentage.
Abbreviation: CI, confidence interval.

Table 2 The Score for KAP of Air Pollution Health Protection Before and After Intervention

Time	Total Score	Knowledge	Attitudes	Practices
Pre-intervention	83.90±8.75	20.45±3.13	31.60±4.03	31.84±4.89
Post-intervention	92.28±4.75	23.20±2.16	34.54±2.09	34.52±2.67
P	<0.01	<0.01	<0.01	<0.01

Note: The score of KAP was expressed with mean ± SD.
Abbreviation: KAP, knowledge, attitude, and practice.

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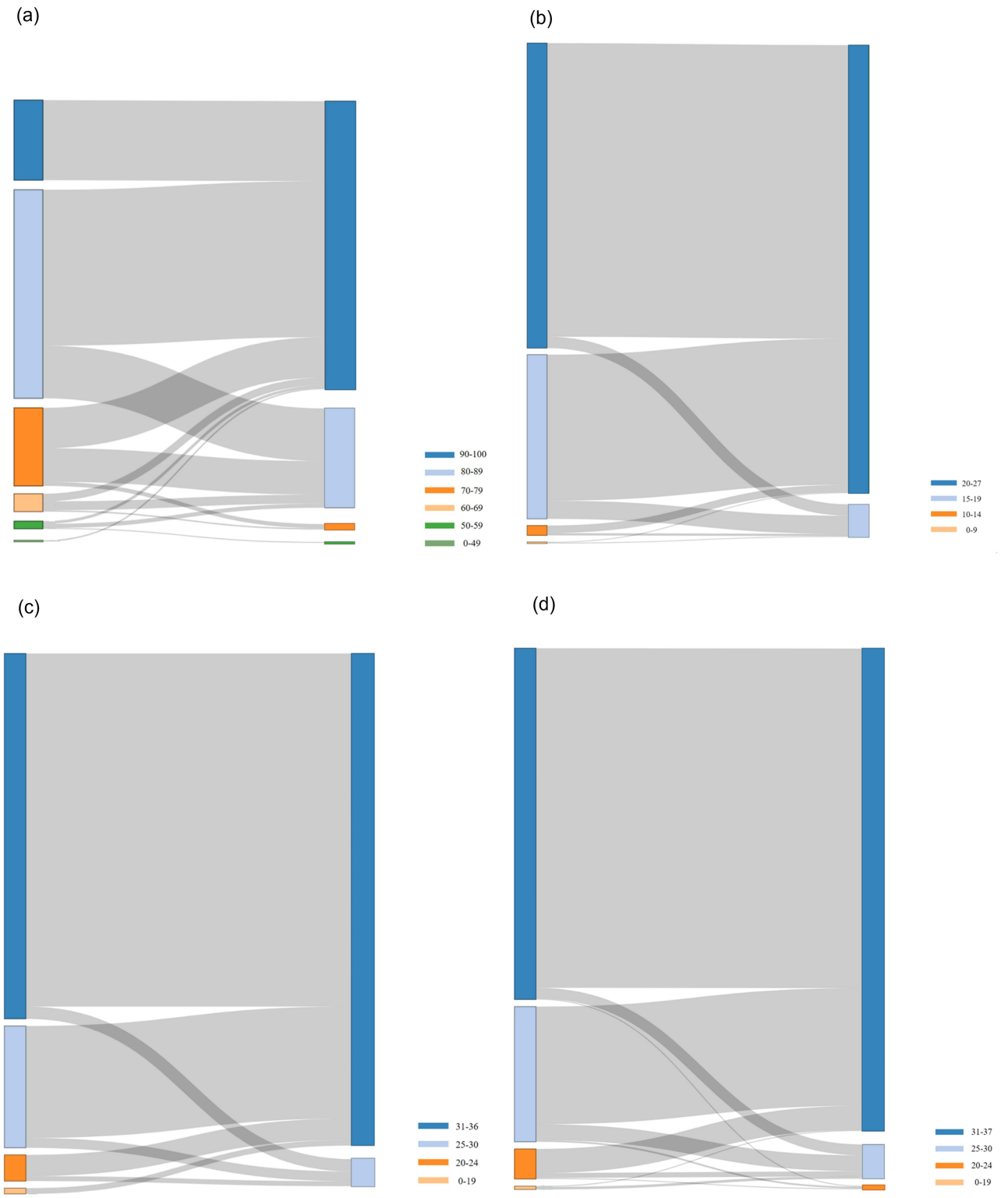

Figure 3 Sankey diagrams showing the pre- and post-intervention changes in the score of KAP and its components. A fraction of 93.54%, 64.72%, 67.09%, and 59.53% of the students experienced an increase in the total score (**a**) of KAP and its component of knowledge (**b**), attitude (**c**), and practices (**d**), respectively.

Table 3 The Score for KAP of Air Pollution Health Protection Before and After Intervention in Prespecified Subgroups

Subgroup	Pre-Intervention	Post-Intervention	Difference (95% CI)	P	Heterogeneity
Sex					
Male	83.71±8.90	92.28±4.55	8.57(−9.42–7.73)	<0.01	0.49
Female	84.11±8.90	92.27±4.55	8.16(−8.96–7.37)	<0.01	
Grade					
Third	84.58±8.90	93.16±4.55	8.58(−9.61–7.52)	<0.01	0.18
Fourth	83.46±8.90	92.66±4.55	9.20(−10.60–7.80)	<0.01	
Fifth	83.67±8.35	91.52±4.60	7.85(−8.65–7.05)	<0.01	
Live with parents					
Yes	84.03±8.71	92.30±4.75	8.27(−8.85–7.69)	<0.01	0.03
No	79.58±8.97	91.53±4.82	11.90(−16.67–7.23)	<0.01	
Father's educational level					
High School or below	82.86±8.32	91.19±5.60	8.33(−10.74–5.93)	<0.01	0.92
Bachelor	83.98±8.64	92.29±4.72	8.31(−8.97–7.65)	<0.01	
Master or above	83.90±9.26	92.52±4.60	8.62(−10.04–7.20)	<0.01	
Mother's educational level					
High School or below	82.55±7.04	90.52±5.45	7.96(−9.41–6.52)	<0.01	0.02
Bachelor	84.49±8.63	92.52±4.67	8.03(−8.68–7.38)	<0.01	
Master or above	81.74±9.81	92.08±4.53	10.30(−12.15–8.53)	<0.01	

Note: The score of KAP was expressed with mean ± SD.
Abbreviations: KAP, knowledge, attitude, and practice; CI, confidence interval.

(Table 2, $P < 0.01$). A fraction of 64.72%, 67.09%, and 59.53% of the students experienced an increase in the component of knowledge, attitude, and practices, respectively (Figure 3).

Results of Subgroup Analyses

Subgroup analysis found that the total score increased after intervention for participants in all subgroups. Notably, the magnitude of the increment significantly differed among subgroups by living with parents and the parent's educational level (Table 3). Students who did not live with their parents and whose mothers had a higher education level experienced more improvement in the total score.

Discussion

We conducted a single-arm pre-post intervention study to explore the effectiveness of knowledge-oriented education on the KAP of APHP for primary students. After a two-month intervention, the scores repeatedly assessed by a structured questionnaire significantly increased and the increment was much more pronounced in students who did not live with their parents and whose mothers received a higher education. Our findings prompted that knowledge-oriented education has an impact on improving KAP of APHP for primary students.

Our study findings are consistent with previous studies demonstrating an improvement in student health through interventions in schools.[14,16,26–29] However, in previous studies, interventions were mostly protective equipment and complex and diverse interactive activities, such as online WeChat, competition activities, and serious games. Studies have found that the intervention measures of knowledge-oriented education are also effective in improving the health knowledge, attitudes, and behaviors of middle and high school students. Schools are places where children receive education, making it easier for them to acquire various knowledge and change negative behaviors. Implementing plans in schools can attract students' attention, promote their mastery of knowledge about air pollution and health protection, and thus encourage their actions in this regard.[30] Therefore, the effectiveness of low-input knowledge-oriented education interventions may have been underestimated. In schools, interventions that focus solely on knowledge-oriented education may also achieve the effect of improving KAP of APHP.

Like previous studies,[14,16] our research results also showed that the increase in scores for practices was smaller than the improvement in knowledge and attitudes. That may be attributed to the fact that changes in practices typically require

longer-term interventions compared to knowledge and attitude gains. It was suggested that future interventions will require more long-term approaches, as well as reinforcement of the transition from knowledge and attitudes acquisition to practices. Schools have the best opportunity to improve or help them develop practices in future interventions.[31]

Air pollution is affecting children, who are more vulnerable to the short- and long-term consequences of high levels of air pollution. Air pollution affects various physiological human functions, including affects various physiological human functions, including the respiratory system, the cardiovascular system, thrombosis and mental imbalances.[32–35] In the absence of intervention, air pollution will soon raise morbidity and death.[36] Primary school is the golden period of physical and psychological development of students, but also the key period of cultivating good behavior habits, although the self-restraint is poor, the plasticity is strong.[37] The interventions should start from an early age in children, particularly the measures for transferring knowledge to behavior change, and improving pupils' practices or helping them develop good habits.[15,30]

Our study provides valuable insights into the potential of knowledge-oriented education interventions in schools for improving students' KAP of APHP. Schools may serve as key settings for the implementation of air pollution prevention strategies. Educational authorities and public health agencies could collaborate to develop comprehensive prevention programs that integrate knowledge-based education into the school curriculum.[38] These programs can include regular air pollution awareness campaigns and hands-on activities such as air quality monitoring projects. By doing so, students can gain a deeper understanding of the health risks associated with air pollution and learn practical ways to protect themselves. Health education activities can be tailored to different age groups and learning levels of students, using a variety of teaching methods such as lectures, group discussions, and multimedia presentations to further enhance students' interest and engagement in learning about air pollution and taking preventive actions.

There was a statistically significant difference among the subgroups living with parents. Family education is related to improving understanding of air pollution,[39] so the intervention effect may be more significant for students who do not live with their parents. The subgroup analysis also revealed that within the subgroup of mothers' education level, the degree of increase in the total score after the intervention gradually rose with the improvement of mothers' education level. Kiuru et al examined the role of parental education level in students' reading fluency in grade 4. The study found that parental education level was one of the control variables that influenced students' reading fluency.[40] Furthermore, Vázquez-Cano et al conducted a study across three countries to analyze the impact of parents' academic qualifications on students' reading efficacy. The results indicated that when mothers had a medium or high level of education, students tended to perform better in reading compared to when only the father had achieved a similar level of education. This suggested that the mother's education level may have a significant influence on students' academic abilities,[41] thereby affecting the effectiveness of knowledge-oriented education interventions on students.

Several limitations should be acknowledged in our study. First, we had not evaluated the impact of interventions implemented for primary school students on their parents. Specifically, in terms of knowledge and attitudes, whether the improvement in students' knowledge and attitudes after knowledge-oriented education interventions in school can enhance parents' knowledge and attitudes, and in turn, parents influence and improve students' knowledge and attitudes, encourage them to develop practices, thus forming a virtuous cycle. Second, in the study design, we did not group intervention measures according to the activities, thereby rendering it challenging to assess the impact of diverse activities. Third, this was a single-arm, open-label study. This design could be influenced by confounding factors and biases. The results will only show the differences before and after the intervention and the feasibility of the intervention. Although the sample size is not small and we observed a significant increment in KAP total score (regardless of its individual components) after intervention, strong evidence of the effectiveness of knowledge-oriented education on KAP of APHP needs to be demonstrated by randomized controlled trials in the future. Fourth, potential confounding factors have not been extensively collected in our pilot study and the interpretation of our results should be of caution. To enhance the generalizability of our results, studies should be conducted in diverse settings with larger and more representative samples and over a longer period to assess the sustainability of the intervention's effects.

Conclusions

Our pilot study found that the KAP of APHP was significantly improved by knowledge-oriented education in primary school students after a short term of intervention, with greater gains in knowledge and attitudes than in practice. In light

of our findings, knowledge-oriented education may be an effective program to improve the ability to cope with air pollution for elementary school students. A well-designed randomized trial is warranted to demonstrate this effectiveness.

Abbreviations

WHO, World Health Organization; SD, Standard deviation; MD, Mean difference; 95% CI, 95% Confidence Interval.

Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author (Hao Peng: penghao@suda.edu.cn) on reasonable request.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Soochow University.

Informed consent to participate in the study was acquired from the parents or legal guardians of all participants prior to the administration of the questionnaire.

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Disclosure

The authors declare no competing interests in this work.

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