Original Article

Effectiveness of the six-step approach guided online training program to improve knowledge of *Mycoplasma pneumoniae* pneumonia among pediatricians: a pretest-posttest study

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Background: In 2023, China witnessed an earlier and more widespread outbreak of *Mycoplasma pneumoniae* pneumonia (MPP). To address this situation, an online training program was designed to enhance the knowledge of MPP among pediatricians in Shanghai, China.

Methods: An online training program on the diagnosis and treatment of MPP, guided by Kern's six-step approach, was developed by the Shanghai Pediatric Clinical Quality Control Center. A pre- and post-training survey was conducted using a 20-item self-administered questionnaire to investigate the pediatricians' knowledge of MPP. A linkage mechanism was established to match pretest/posttest questionnaires using personal identifiers. Paired *t*-tests and McNemar tests were performed to measure the differences, as appropriate, between pre- and post-training groups. A higher survey score indicated better knowledge.

Results: There were 289 participants performed pre- and post-tests. The average age of the respondents was 38.7 years (standard deviation: 8.9). Over 80% of the participants were primary (32.5%) and intermediate (47.8%) pediatricians. Those from specialized hospitals accounted for the highest proportion (41.5%). The post-training group achieved significantly higher total scores than the pre-training group (91.3 *vs.* 67.7, t=22.48, P<0.001), regardless of the professional titles or hospital levels (all P<0.001). The accuracy rates of each question increased significantly in the post-training group (all P<0.001).

Conclusions: The online training program effectively enhanced pediatricians' understanding of diagnosing and treating MPP. It is recommended to maintain continuous education and training targeting all healthcare providers.

Keywords: *Mycoplasma pneumoniae* pneumonia (MPP); pretest-posttest study; Kern's six-step approach; online training

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Introduction

Mycoplasma pneumoniae (MP) is one of the most common causes of community-acquired pneumonia (CAP) in children (1), with up to 10% of MP-infected children developing *Mycoplasma pneumoniae* pneumonia (MPP) (2). MPP outbreaks may occur every 3 to 7 years and last for up to 2 years (3,4), with the latest occurrence documented in 2019. Notably, nationwide non-pharmaceutical interventions (NPI) against coronavirus disease 2019 (COVID-19), such as strict face mask-wearing and population movement restrictions, have prevented the spread of MP and led to a decrease in MPP incidence over the past 3 years (5). However, this may result in insufficient immunity. With downgraded NPIs and a growing susceptible population (6), the year 2023 witnessed an earlier and more widespread outbreak of MPP in China, with cases increasing from April and reaching a peak from October to November (7).

Although most MPP cases are mild and self-limiting, approximately 0.5–2.0% of cases are accompanied by severe complications, requiring early detection and intervention (8,9). Macrolide antibiotics are the primary clinical treatment for MPP. However, macrolide-resistant mycoplasma pneumonia (MRMP) has emerged widely in recent years, especially in Asian countries, driven by variations in the 23S rRNA gene (10). The macrolide resistance of MPP exceeded 90% between 2009 and 2012 in Beijing (11). Due to the challenges posed by antibiotic resistance and the rising prevalence of severe cases, there is an imperative need for effective MPP management. The first step should involve training pediatricians to enhance their understanding of MPP, particularly in early detection and treatment, especially for macrolide-unresponsive, refractory, and severe cases.

However, traditional in-person training faces constraints such as limited faculty and resources, and the difficulty of gathering everyone at the same time. In contrast, online training in medical education, accelerated by the COVID-19 pandemic, has overcome these obstacles and become mainstream (12). It has demonstrated convenience and flexibility, thus attracting as many participants as possible (13). Kern's six-step approach is a systematic approach to online curriculum development and is suitable for establishing short educational sessions (14). Based on this framework, we designed an online training program tailored for pediatricians from all levels of hospitals in Shanghai. This study aimed to evaluate the impact of the training program on enhancing the pediatricians' understanding of MPP. We present this article in accordance with the STROBE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-24-53/rc).

Highlight box

Key findings

- The post-training group demonstrated significantly improved knowledge of *Mycoplasma pneumoniae* pneumonia (MPP) compared to the pre-training group, regardless of professional titles or hospital levels.

What is known and what is new?

- Kern's six-step guided online training programs is effective in enhancing knowledge among healthcare providers.
- This study showed the effectiveness of a tailored online training program for pediatricians in enhancing their knowledge of MPP diagnosis and treatment. The program was effective across different professional titles and hospital levels, indicating its broad applicability.

What is the implication, and what should change now?

- Continuous education and training targeted at all healthcare providers, including pediatricians, is crucial in combating MPP outbreaks.
- Online training programs can be a cost-effective and efficient way to disseminate knowledge and enhance clinical skills.

Methods

Study design

This study was conducted in two stages. In the first stage, Kern's six-step approach guided online training program was designed by experts from the Shanghai Pediatric Clinical Quality Control Center (SPCQCC). In the second stage, pediatricians from all levels of hospitals (i.e., primary, secondary, tertiary, and specialized) were invited to take part in this online training program. Subsequently, pre- and post-training anonymous questionnaires were sent to these participants.

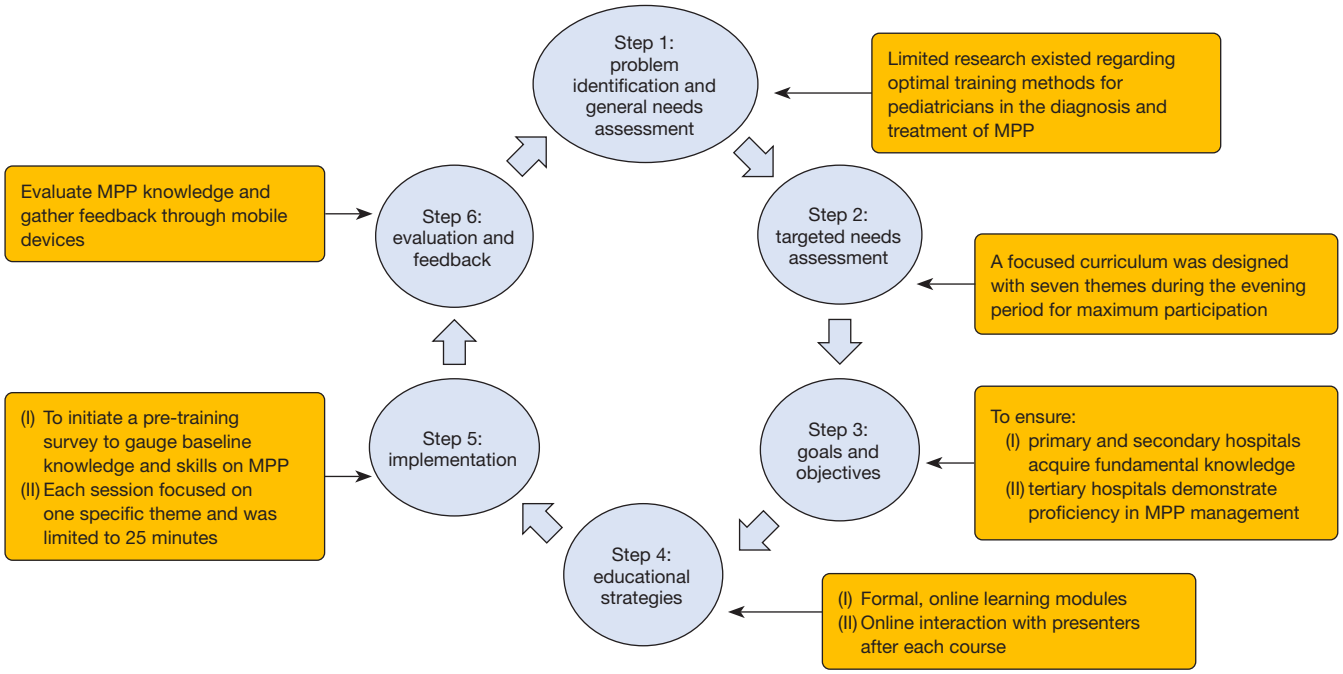

Figure 1 Key aspects of the online training program guided by Kern's six-step approach. MPP, *Mycoplasma pneumoniae* pneumonia.

Designing and implementing an online training program

To further standardize the diagnosis and treatment process of MPP in Shanghai, SPCQCC convened a multidisciplinary team of experts from pediatric respiratory, critical care, and infectious diseases. The contents of the online training program were based on the latest clinical guidance for the management of pediatric MPP and CAP (15,16), focusing on MPP diagnostic criteria and treatment modalities. *Figure 1* summarizes Kern's framework and outlines the key aspects of the curriculum design.

Step 1: problem identification and general needs assessment

Limited research exists regarding optimal training methods for healthcare professionals in the diagnosis and treatment of MPP. Preliminary studies suggest a positive impact of online training in CAP for medical workers, indicating potential application. Therefore, an online training program was developed on the platform of the Tencent Meeting, where all pediatricians from Shanghai had access to this program.

Step 2: targeted needs assessment

There is no documented training program focusing on MPP for pediatricians. Therefore, a preliminary survey was conducted to understand knowledge gaps, and face-to-face communication was initiated with experts to gather their opinions on priority educational areas for MPP. Recognizing the difficulties in self-learning and offline gatherings for pediatricians with tight schedules, an online curriculum design with shareable teaching materials was implemented. Finally, a focused curriculum was designed with seven themes during the evening period for maximum participation.

Step 3: goals and objectives

The objective was to establish a structured approach, ensuring that primary and secondary hospitals acquired fundamental diagnostic and therapeutic knowledge for treating mild cases and facilitating timely referrals for severe cases. Simultaneously, tertiary hospitals should demonstrate proficiency in MPP management, develop the capacity to promptly identify severe cases, conduct pathogen testing, and administer medication judiciously.

Step 4: educational strategies

Our curriculum included two key educational components: (I) formal and online learning modules; and (II) interactive sessions with presenters after each course. The MPP curriculum integrated theoretical knowledge and clinical case studies, utilizing diverse teaching methods such as text,

images, and videos.

Step 5: implementation

First, we initiated a pre-training survey (Appendix 1) to gauge baseline knowledge and skills on MPP. Course arrangement and the presenter's academic rank are shown in Table S1. Each session focused on one specific theme and was limited to 25 minutes for high-quality output. All of these courses were delivered by pediatric respiratory experts from top hospitals in China. After the training, each participant completed the post-training survey, which included knowledge evaluation and formal feedback.

Step 6: evaluation and feedback

An immediate assessment of MPP knowledge was achieved using a post-training questionnaire survey. The 20-item electronic questionnaire was divided into three dimensions: the mechanism (1 item), diagnosis (10 items), and treatment (9 items) sections, with 5 single-choice and 15 multiple-choice questions. Each correct answer earned 5 points, resulting in a total maximum score of 100. Participants provided feedback including satisfaction with the training program, and whether they would recommend the training program to other pediatricians.

In the current analysis, we excluded participants who resubmitted the survey and those who had no available data on age, hospital level, or professional title. Then, a linkage mechanism was established to match pretest/posttest questionnaires using personal identifiers.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study protocol was approved by the ethics committee of the Children's Hospital of Fudan University (No. 2022-44). A letter from SPQCC was sent to participants to inform them about the significance and use of the questionnaire, and informed consent was deemed to be given after completion of the questionnaire.

Statistical analysis

The continuous variables with normal distributions were expressed as mean with standard deviation (SD). The categorical data were expressed as n (%). We also stratified the participants according to professional titles and hospital levels. One-way analysis of variance was used to compare differences in total scores among more than two groups. Paired *t*-tests and McNemar tests were performed to investigate the differences as appropriate between pre- and post-training groups. All data were analyzed using R version 3.6.2. A P value of <0.05 was considered statistically significant.

Results

In total, 494 and 593 participants were included in the pre-training and post-training groups respectively. This resulted in 289 records matched for pretest-posttest analysis (i.e., before-after study) (*Figure 2*).

Table 1 summarizes the main characteristics of participants matched for pretest and posttest analysis. The average age of the respondents was 38.7 years (SD: 8.9; range: 23.0–59.0 years). Over 80% of the participants were primary (32.5%) and intermediate (47.8%) pediatricians. Those from specialized hospitals accounted for the highest proportion (41.5%).

Table 2 shows the difference in the total score among various professional titles and hospital levels before and after the training. In the pre-training group, the total score varied across professional titles, with scores of 66.6, 66.6, 71.7, and 73.3, respectively, showing an increase with higher levels of professional titles, although not statistically significant (F=1.60, P=0.19). A similar trend was observed among hospital levels (F=1.79, P=0.15). In the post-training group, no significant difference was observed either in the professional title (F=0.66, P=0.58) or in the hospital level (F=0.81, P=0.49).

Table 3 shows the results of stratified analyses. The total score of the post-training group was significantly higher than that in the pre-training group (91.3 *vs.* 67.7, t=22.48, P<0.001), regardless of the professional titles or hospital levels (all P<0.001). Nevertheless, there were some exceptions. For example, in the diagnosis section, no significant difference was observed among senior pediatricians (45.3 *vs.* 40.7, t=1.86, P=0.08).

Table 4 demonstrates the results of each question in the two groups. The findings showed that respondents in the post-training group grasped better knowledge than those in the pre-training group (all P<0.001). Over 90% of the respondents in the pre-training group answered correctly in questions such as (I) Q3: extra-pulmonary manifestations of MP infection (91.0%), (II) Q10: imaging manifestations of severe pneumonia (94.1%), and (III) Q13: first line antibiotics for MPP (98.3%). However, the following questions exhibited a failing grade (<60%): (I) Q4: which of the following statement can confirm the diagnosis of MPP (47.8%); (II) Q6: when should plastic bronchitis be

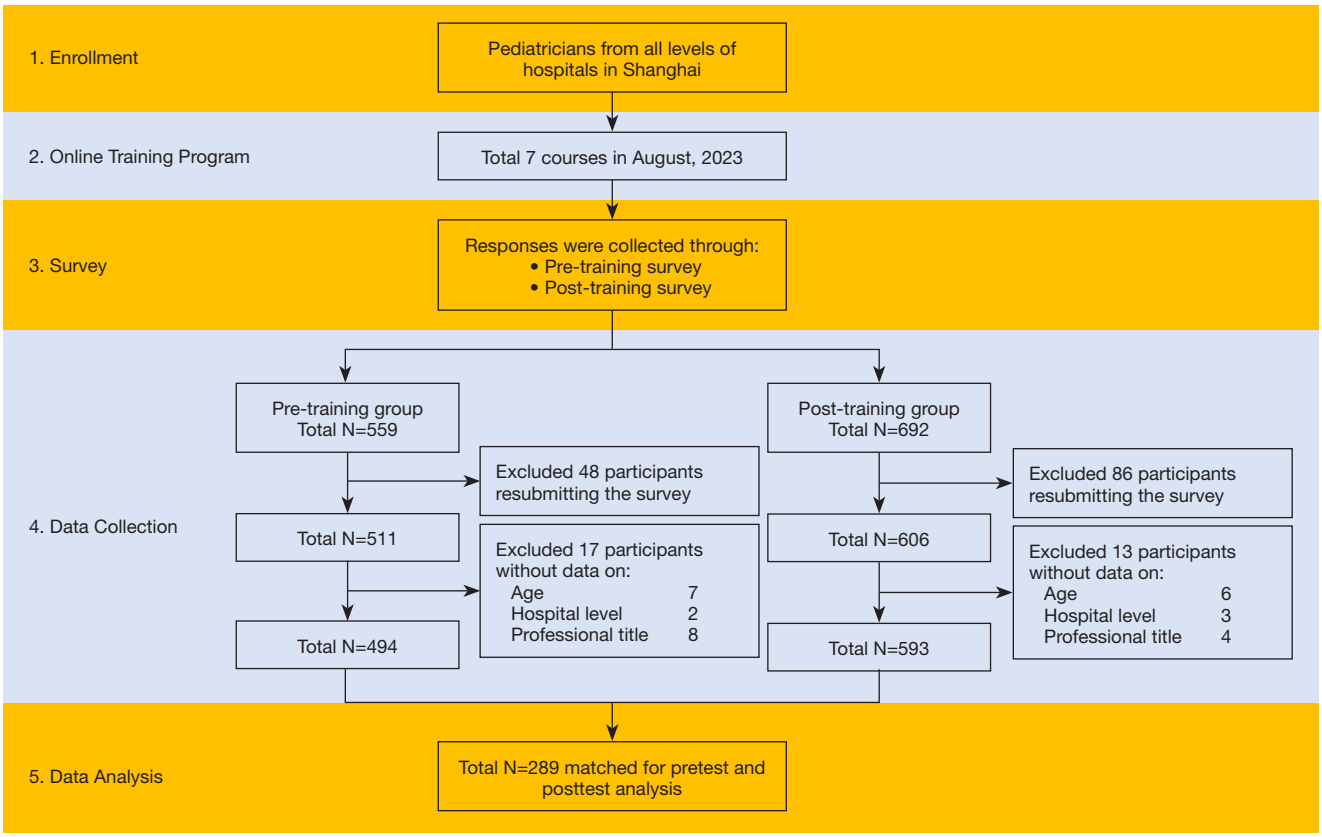

Figure 2 Flowchart of the study participants.

Table 1 Baseline characteristics of the study participants

Variables	Overall (n=289)
Age, years, mean (SD)	38.7 (8.9)
Professional title†, n (%)	
Primary	94 (32.5)
Intermediate	138 (47.8)
Associate senior	42 (14.5)
Senior	15 (5.2)
Hospital level, n (%)	
Primary	35 (12.1)
Secondary	74 (25.6)
Tertiary	60 (20.8)
Specialized	120 (41.5)

†, pediatricians in China are often classified as "primary", "intermediate", "associate senior", and "senior" grades according to their skill levels and specialization. SD, standard deviation.

considered? (42.2%); (III) Q11: relative contraindications for bronchoscopy (20.1%); (IV) Q12: indications for corticosteroids in MPP (30.4%); (V) Q19: anticoagulation can be considered for severe patients with D-dimer elevated × normal upper limit (34.6%); and (VI) Q20: greatest benefit from thrombolytics if given within × hours of PE symptoms (37.7%). The accuracy rates of these questions increased significantly in the post-training group (all P<0.001).

Discussion

This study was conducted to evaluate the effectiveness of an MPP-oriented training program for pediatricians. Before the training, a preliminary survey was conducted at different levels of hospitals in Shanghai, revealing knowledge and skill limitations in specific areas. To address this problem, a training program was designed using Kern's six-step

Table 2 Differences of the total score in different professional titles and hospital levels in pre- and post-training groups

Variables	N	Pre-training group			Post-training group		
		Total score†	*F*	P	Total score†	*F*	P
Overall	289	67.7 (17.1)			91.3 (12.6)		
Professional title‡			1.60	0.19		0.66	0.58
Primary	94	66.6 (19.3)			92.3 (12.2)		
Intermediate	138	66.6 (14.7)			91.4 (12.6)		
Associate senior	42	71.7 (18.6)			90.1 (11.9)		
Senior	15	73.3 (18.5)			88.0 (16.8)		
Hospital level			1.79	0.15		0.81	0.49
Primary	35	62.7 (14.5)			93.0 (12.8)		
Secondary	74	66.2 (13.8)			89.6 (12.4)		
Tertiary	60	70.2 (12.8)			91.1 (10.8)		
Specialized	120	68.9 (21.0)			92.0 (13.5)		

†, values are presented as mean (standard deviation). ‡, pediatricians in China are often classified as "primary", "intermediate", "associate senior", and "senior" grades according to their skill levels and specialization.

approach for curriculum development. To the best of our knowledge, this is the first study to assess the knowledge of MPP among pediatricians and the difference between post-training and pre-training groups. The findings support the effectiveness of implementing an online training program for pediatricians to improve their MPP-related knowledge. The program has also been shown to be effective in improving the knowledge of MPP among pediatricians.

Although no previous training studies focused on MPP, a training program related to ventilator-associated pneumonia found that nurse-led education significantly enhanced nurses' understanding and adherence to ventilator care bundle practices (17). Similarly, in a study involving 300 community pharmacists, a knowledge questionnaire about asthma was used to evaluate their knowledge before and after a 4-h training program. The study found that a short training program was effective in improving the knowledge of the pharmacists (18). Both two studies used a pretest-posttest design and conducted paired sample *t*-tests to assess the improvement of the training program, aligning closely with the outcomes of our study.

The results of our study indicated that certain areas were well-understood by all the participants, such as radiological manifestations of severe pneumonia. This can be attributed to the experience gained during the COVID-19 pandemic, in which healthcare workers became quite familiar with pneumonia-related knowledge (19). Moreover, respiratory disease training programs have been conducted in Shanghai in the past 3 years (13), adhering to the guidelines established by the World Health Organization (20) and the Chinese National Health Commission for the diagnosis and treatment of pediatric CAP (16).

A statistically significant difference was observed in the following areas between the two groups: MPP detection methods, bronchoscopy, and corticosteroid indications. Firstly, detection of MP can be achieved by culture, serology, or molecular-based methods and each of these methods possesses advantages and disadvantages, such as speed, sensitivity, and specificity (21-24). It is noted that limited access to testing tools in certain hospitals may contribute to the knowledge gaps. Secondly, flexible bronchoscopy with bronchoalveolar lavage plays a role in the timely detection of infections and improves the recovery of lung damage in MPP patients (25). Due to the hierarchical medical system in Shanghai, many hospitals, including primary and secondary hospitals may lack the license to perform bronchoscopy for children, limiting access to the tool and relevant knowledge. Nevertheless, training these pediatricians is crucial for facilitating prompt patient transfers. Similarly, some pediatricians may rarely encounter severe MPP cases or complications (26) and are unfamiliar with the indications for corticosteroids.

The main strength of our study is its timely implementation in early August 2023, before the 2023 MPP

Table 3 Score comparisons between pre-training and post-training groups in different professional titles and hospital levels

Variables	Total (20-item, full mark =100)					Diagnosis (10-item, full mark =50)					Treatment (9-item, full mark =45)				
	Pre-training group	Post-training group	Difference (post – pre)	*t*	P	Pre-training group	Post-training group	Difference (post – pre)	*t*	P	Pre-training group	Post-training group	Difference (post – pre)	*t*	P
Total score	67.7 (17.1)	91.3 (12.6)	23.6 (21.5–25.7)	22.48	<0.001	38.1 (8.6)	46.8 (5.4)	8.7 (7.6–9.7)	16.47	<0.001	25.2 (10.0)	39.7 (8.1)	14.5 (13.2–15.7)	22.57	<0.001
Professional title[†]															
Primary	66.6 (19.3)	92.3 (12.2)	25.6 (21.5–29.8)	12.35	<0.001	37.2 (9.3)	47.2 (4.9)	9.9 (8.0–11.9)	9.93	<0.001	25.0 (10.7)	40.3 (7.6)	15.3 (13.0–17.6)	13.27	<0.001
Intermediate	66.6 (14.7)	91.4 (12.6)	24.8 (22.0–27.5)	17.75	<0.001	37.9 (8.1)	46.7 (5.6)	8.8 (7.3–10.3)	11.97	<0.001	24.2 (8.9)	39.8 (8.1)	15.5 (13.8–17.3)	17.34	<0.001
Associate senior	71.7 (18.6)	90.1 (11.9)	18.5 (13.2–23.7)	7.06	<0.001	39.9 (8.9)	46.8 (4.9)	6.9 (4.6–9.2)	5.98	<0.001	27.6 (10.7)	38.5 (8.0)	10.8 (7.3–14.4)	6.18	<0.001
Senior	73.3 (18.5)	88.0 (16.8)	14.7 (6.9–22.4)	4.07	<0.001	40.7 (7.3)	45.3 (6.9)	4.7 (–0.7–10.1)	1.86	0.08	28.3 (12.2)	38.0 (10.8)	9.7 (4.9-14.4)	4.38	0.001
Hospital level															
Primary	62.7 (14.5)	93.0 (12.8)	30.3 (23.7–36.8)	9.38	<0.001	35.0 (8.7)	47.1 (5.6)	12.1 (8.5–15.8)	6.83	<0.001	23.0 (8.4)	41.0 (7.6)	18.0 (14.3–21.7)	9.99	<0.001
Secondary	66.2 (13.8)	89.6 (12.4)	23.4 (20.1–26.7)	14.10	<0.001	38.0 (7.6)	46.2 (6.0)	8.2 (6.3–10.2)	8.55	<0.001	23.8 (8.1)	38.6 (7.6)	14.8 (12.8–16.8)	14.70	<0.001
Tertiary	70.2 (12.8)	91.1 (10.8)	20.9 (16.9–24.9)	10.42	<0.001	38.8 (7.3)	46.7 (4.3)	7.8 (5.7–9.9)	7.49	<0.001	26.9 (7.5)	39.4 (7.9)	12.5 (10.0–15.0)	10.05	<0.001
Specialized	68.9 (21.0)	92.0 (13.5)	23.2 (19.5–26.8)	12.59	<0.001	38.8 (9.5)	47.1 (5.4)	8.4 (6.7–10.0)	10.00	<0.001	25.8 (12.2)	40.0 (8.6)	14.2 (11.9–16.5)	12.42	<0.001

Values are presented as mean (standard deviation) or estimate (95% confidence interval). [†], pediatricians in China are often classified as “primary”, “intermediate”, “associate senior”, and “senior” grades according to their skill levels and specialization.

Table 4 Performance on each question using the McNemar test for paired data

Category	Questions	Pre-training group (% correct)	Post-training group (% correct)	χ^2	P
1. Mechanism	What are the pathogenesis mechanisms of refractory MPP	88.2	97.6	23.52	<0.001
2. Diagnosis	Macrolide-unresponsive MPP refers to children who have undergone standard treatment with macrolide antibiotics but still have persistent fever, worsening clinical signs and pulmonary imaging after _[†]	77.9	95.5	38.82	<0.001
3. Diagnosis	Extra-pulmonary manifestations of MP infection include	91.0	97.9	16.67	<0.001
4. Diagnosis	Which of the following statement can confirm diagnosis of MPP	47.8	86.5	99.56	<0.001
5. Diagnosis	Imaging manifestations of MPP include	77.5	96.2	39.41	<0.001
6. Diagnosis	When should plastic bronchitis be considered?	42.2	75.4	64.00	<0.001
7. Diagnosis	Intrapulmonary complications of MPP include	75.4	96.2	51.43	<0.001
8. Treatment	Indications for bronchoscopy in MPP	72.7	89.6	29.64	0.001
9. Diagnosis	Clinical manifestations of severe pneumonia include	88.2	95.8	12.10	<0.001
10. Diagnosis	Imaging manifestations of severe pneumonia	94.1	99.7	14.22	<0.001
11. Treatment	Relative contraindications for bronchoscopy	20.1	72.0	133.93	<0.001
12. Treatment	Indications for corticosteroids in MPP	30.4	79.6	127.62	<0.001
13. Treatment	First line antibiotics for MPP[†]	98.3	100.0	NA	NA
14. Treatment	Antibiotics for resistant MPP often include	70.2	90.7	44.06	<0.001
15. Treatment	Besides anti-infectives, other treatment of MPP includes	73.4	96.5	59.85	<0.001
16. Treatment	Indications for IVIG	66.4	94.1	72.73	<0.001
17. Diagnosis	Acute pulmonary embolism triad includes	88.6	96.9	16.94	<0.001
18. Diagnosis	First line test for pulmonary embolism diagnosis[†]	79.6	95.8	41.68	<0.001
19. Treatment	Anticoagulation can be considered for severe patients with D-dimer elevated × normal upper limit[†]	34.6	87.5	141.87	<0.001
20. Treatment	Greatest benefit from thrombolytics if given within × hours of PE symptoms[†]	37.7	83.0	112.16	<0.001

[†], these are single-choice questions. MPP, *Mycoplasma pneumoniae* pneumonia; MP, *Mycoplasma pneumoniae*; IVIG, intravenous immunoglobulin; PE, pulmonary embolism; NA, not applicable.

peak, which may exert a positive impact on reducing the severity rate of MPP. However, several limitations must be noted. Firstly, no control group was set for this analysis. We cannot rule out the possibility of the influence of other information sources and potential confounding factors. Secondly, while these participants were from all levels of hospitals, the results of this intervention may not be representative of all pediatricians (27). Thirdly, according to a systematic review conducted by Marino *et al.* (28), approximately 9% of infants hospitalized with COVID-19 exhibited co-infection with MP. Despite this significant prevalence, co-infection has been overlooked in the current training, leading to a critical knowledge gap. Therefore, it is imperative that future training addresses this gap to improve the comprehensive clinical diagnosis and treatment capacity. Finally, additional survey distribution could occur at 3 and 6 months after completion of the curriculum to evaluate the interim and long-term impact of the training program.

Conclusions

Pediatricians play an important role in preventing the outbreak of MPP in medical settings. This study suggests an overall improvement in knowledge of MPP with the

implementation of Kern's step-six approach guided online training program. Therefore, it is recommended to maintain continuous education and training targeted to all healthcare providers.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tp.amegroups.com/article/view/10.21037/tp-24-53/rc

Data Sharing Statement: Available at https://tp.amegroups.com/article/view/10.21037/tp-24-53/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tp.amegroups.com/article/view/10.21037/tp-24-53/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study protocol was approved by the ethics committee of the Children's Hospital of Fudan University (No. 2022-44). A letter from SPQCC was sent to participants to inform them about the significance and use of the questionnaire, and informed consent was deemed to be given after completion of the questionnaire.

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