

Follow-up study on management of chronic obstructive pulmonary disease in Hunan Province, the People's Republic of China

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Background: In 2009, our study showed an extreme imbalance and disparity in COPD-related health resources allocation at three levels of public hospitals (PHs) in Hunan Province of the People's Republic of China, especially in second-level PHs. Moreover, most Chinese citizens accept their health care services in first- and second-level PHs for economic and geographical reasons, as well as because of the incomplete transfer system in the health care services. To improve diagnosis and treatment ability of pulmonologists in second-level PHs, an intervention that provided training combined with spirometry equipment was carried out in three PHs from six second-level PHs. The aim of this follow-up study was to evaluate the changes associated with COPD-related health resources allocation and the effect of the intervention 4 years later.

Methods: The data regarding the availability of spirometers, inhalation agents for COPD, and COPD-related health care education for local residents were collected from 57 PHs in 2009 and 48 PHs in 2013. Pulmonologists working in these PHs were asked to complete a questionnaire individually. Six second-level PHs (three in the intervention group and the other three in the control group [without training and spirometry equipment]) that further took part in the survey in 2009 were reevaluated to determine the doubtful diagnostic ratio and the confirmation ratio of COPD. The differences between 2009 and 2013 data was analyzed.

Results: A total of 762 questionnaires were completed. Compared with 2009, spirometer-equipped ratio raised from 40% to 69% in 2013 ($P=0.03$). The overall inhalation agent-equipped ratio increased from 58% in 2009 to 88% in 2013 ($P=0.001$). The total rate of health education raised from 35% in 2009 to 63% in 2013 ($P=0.04$). In total, 204 pulmonologists from six PHs (selected for study in 2009) completed the questionnaires in 2013. The median score of COPD knowledge questionnaire in the intervention group was higher than that of the control group (80 vs 50, respectively, $P<0.01$). Further, the clinical doubtful diagnostic ratio (15%) and the diagnosis ratio of COPD (3%) in the intervention group were higher than in the control group (4% and 1%, respectively, $P<0.05$) even after 4 years.

Conclusion: COPD-related health resources allocation improved in the 4 years following intervention at three levels of PHs in the People's Republic of China. Short-term training combined with spirometry equipment had a sustained effect on improving the physicians' understanding and diagnosis ability of COPD.

Keywords: COPD, public hospitals, pulmonologists, training, China

Introduction

COPD is a common preventable and treatable disease that has been a growing health problem, and remains a major consumer of health care resources in the world.¹ Unfortunately, a majority of studies from the general population and primary care



have reported that a high proportion of individuals fulfilling the COPD diagnosis criteria remain undiagnosed.^{2,3}

In the People's Republic of China, all public hospitals (PHs) are ranked at three levels (first-, second-, and third-level hospitals, higher levels are better) by the Ministry of Health of the local and central bureau according to the physical size of the medical campus, the number of inpatient beds, the type of medical equipment, etc.⁴ Generally, higher level PHs are built in bigger cities, which lead to a huge disparity in health care resources and services between cities and rural areas.⁵ As in our previous study, we found an extreme imbalance and disparity in spirometry equipment, availability of inhaler agents, and COPD-related health care education at three levels of PHs in Hunan Province of the People's Republic of China, especially in the first- and second-level PHs.⁶ Moreover, a serious shortage of medical specialists exists in rural areas because most specialists preferred to work in high-level hospitals located in urban areas.⁷ In addition, the educational level of the majority of physicians in rural areas ranges from 3 to 5 years of medical college after secondary school training.⁶ Most physicians who are unfamiliar with COPD guidelines will have difficulties understanding the treatment options, outcomes, and prognosis of COPD.^{8,9} Therefore, improving the physicians' diagnosis and treatment ability of diseases is urgent.

Providing continued medical education to physicians can be effective in improving their psychomotor skills and application of knowledge.¹⁰ In the People's Republic of China, learning in a top-level hospital is an efficient way of continuing medical education for rural doctors who want to improve their knowledge of medicine. Even so, not all rural doctors have chances to continue their medical education in a top-level hospital. Similar to the findings of our previous study, we found that short-term training combined with spirometry equipment could improve physicians' knowledge about COPD, including the ability to diagnose COPD and assess its severity.¹¹

With a rapid growth in the Chinese economy and deepening reforms in the Chinese health care system, questions about imbalance and disparity in the COPD-related health resources allocation arise, and we wondered if the intervention was still working. The aim of this follow-up study was to evaluate the changes of COPD-related health resources allocation and the effect of the intervention 4 years later.

Materials and methods

Participants and trial design

The Second Xiangya Hospital of Central South University institutional review board approved the study. Written informed consent was obtained from all the participants.

A clustering-stratified random sampling, cross-sectional study was used to investigate the COPD-related health resources allocation at three levels of PHs in Hunan Province, the People's Republic of China, in 2009. At the same time, a questionnaire was sent to pulmonologists in those PHs, including questions about baseline characteristics (literacy and professional title) and knowledge about COPD. In 2013, we collected data from the same PHs to investigate the COPD-related health resources allocation and sent the same questionnaire to pulmonologists in those PHs to survey their knowledge about COPD.

In addition, we used a randomized parallel-group controlled design to compare the effects of an intervention in 2009, including a 1-hour training course and supplying spirometry equipment, with a control that did not receive the intervention.

Six second-level PHs without spirometers were randomized using a random number generator and allocated to treatment vs control groups at a ratio of 1:1.

Diagnosis and treatment level of pulmonologists in those PHs was calculated according to the referred medical records in the same 3-month period before the intervention (October 1, 2008 to December 31, 2008), during (January 1, 2009 to March 31, 2009), and at the follow-up visit (January 1, 2013 to March 31, 2013).

Survey questionnaire design

Two questionnaires were used in this study. One design included hospital levels, investigating whether their wards had spirometers, types of inhaled bronchodilator medications used, and whether COPD-related health education was provided for patients or not. The other questionnaire aimed at investigating the physicians' knowledge about COPD and was devised by a pulmonary expert advisory group, which was based on the existing published recommendations of the Chinese COPD guidelines.¹² The questionnaire intended to test the COPD knowledge was designed to investigate the demographic information, professional titles, and educational levels of pulmonologists, and to test their knowledge of COPD diagnosis and treatment based on the COPD guidelines. In total, ten single-choice questions were presented including main manifestations of COPD, pathogenesis of COPD, diagnostic criteria, evaluation of pulmonary function, guideline criteria for severity grading, therapy for COPD including pharmacotherapy and oxygen, the common causes of acute exacerbation COPD, and indications for noninvasive ventilation. Every question was worth 10 points. Not answered and wrong answers were given a 0 score. The reliability and validity of the questionnaire had been tested

before. Briefly, Cronbach's alpha score measuring the internal consistency of questions was 0.73 and 0.77 for the first and the second questionnaires, respectively.⁶

The questionnaires were administered by a research assistant and surveyed anonymously. All pulmonologists participated by completing the questionnaires by themselves.

Outcomes

Allocation of COPD-related health care resources

Spirometer-equipped ratio, inhalation agent-equipped ratio, and availability ratio of COPD-related health care education at three levels of PHs in 2009 and 2013 were collected.

Pulmonologists' basic knowledge about COPD

Scores of the questionnaire investigating the COPD knowledge of pulmonologists were compared among the pulmonologists working at different levels of PHs in 2009 and 2013. Scores based on education levels or professional titles of different pulmonologists were calculated in 2013.

Effect of short-term training

Pulmonologists' doubtful diagnosis ratio and confirmation diagnosis ratio of COPD were calculated in six second-level PHs in the intervention group and the control group. Consistent with the ease of data collection for the study, we only collected data on all hospitalized patients over the age of 40 years from the referred medical records in both groups to compare the pulmonologists' clinical doubtful diagnostic ratio and diagnosis ratio of COPD. "Clinical doubtful diagnosis ratio" was defined as the number of hospitalized patients with clinical doubtful diagnosis of COPD/total number of hospitalized patients over the age of 40×100%; "diagnosis ratio of COPD" was defined as the number of hospitalized patients diagnosed with COPD/total number of hospitalized patients over the age of 40×100%.

Data analysis

All data were input and analyzed by using Statistical Product and Service Solutions 17.0 (SPSS 17.0) software. Chi-square test was used to compare results about spirometer-equipped ratio, inhalation agent-equipped ratio, availability rate of health education, clinical doubtful diagnostic ratio of COPD, diagnosis ratio of COPD, pulmonologists' education levels and professional titles, and accuracy of COPD questionnaires. Differences between the groups were considered significant if $P \leq 0.05$. Comparison of pulmonologists' scores was performed using a nonparametric test (Wilcoxon). The Mann-Whitney U method was used to compare two

groups, whereas the Kruskal-Wallis H method was used for multiple groups. Spearman's rank correlation method was used to acquire multivariate linear regression analysis of pulmonologists' scores.

Results

Baseline characteristics

In 2009, there were 44 third-level PHs, 292 second-level PHs, and 193 first-level PHs. We randomized 57 PHs at the three different levels. In 2013, there were 48 PHs because nine first-level PHs were removed, six of which had changed their hospital levels and three had incomplete data. In 2009, questionnaires were sent to 893 pulmonologists in 57 PHs, and 869 were returned, with a recovery rate of 97%. Only 846 questionnaires were effective according to the study design, resulting in an effective rate of 95%. In 2013, 792 questionnaires were sent to pulmonologists in 48 PHs, and 776 questionnaires were returned, with a recovery rate of 98%. Only 762 questionnaires were effective and fourteen were excluded because of any unanswered question, resulting in an effective rate of 98%. The baseline characteristics of PHs and pulmonologists in 2009 and 2013 are shown in Table 1.

Changes associated with COPD-related health resources allocation over the 4 years

Allocation of spirometers

The total spirometer-equipped ratio in 2013 was 69%, and 0%, 75%, and 100% for the first-, second-, and third-level PHs, respectively. Significant differences between the levels of PHs in 2013 were still seen among the spirometer-equipped ratios ($\chi^2=27.05$, $P<0.0001$). Compared with the condition in 2009, the equipped ratio was higher in the second-level PHs in 2013 ($\chi^2=8.39$, $P=0.003$). There was no change in the first- and third-level PHs between the 2 years ($P>0.05$) (Table 2).

Allocation of inhalation agents

The total inhalation agent-equipped ratio in 2013 was 88%, and 33%, 100%, and 100% for the first-, second-, and third-level PHs, respectively. Significant differences were observed among the inhaled agent-equipped ratios at different levels of PHs in 2013 ($\chi^2=29.71$, $P<0.0001$). Significant difference regarding equipped ratio was observed in the second-level PHs between 2009 and 2013 ($\chi^2=8.39$, $P=0.004$). There was no change in the third-level PHs during the 4 years. No difference existed in the first- and third-level PHs between 2009 and 2013 ($\chi^2=1.29$, $P=0.26$) (Table 2).

Table 1 Baseline characteristics of public hospitals (PHs) and pulmonologists

Variable	Total		Third-level PHs		Second-level PHs		First-level PHs	
	2009	2013	2009	2013	2009	2013	2009	2013
PHs (n)	57	48	15	15	24	24	18	9
Pulmonologists (n)	846	762	192	204	559	506	95	52
Pulmonologists' educational level (n)								
High	82	109	73	93	9	16	0	0
Medium	604	520	117	111	424	380	63	29
Low	160	133	2	0	126	110	32	23
Pulmonologists' professional level (n)								
Senior	115	124	40	45	55	67	20	12
Intermediate	378	332	100	98	244	205	34	29
Junior	353	306	52	61	260	234	41	11

Notes: Pulmonologists' educational level was categorized into three levels: high educational level means PhD and master's degree of medicine, median means bachelor's degree of medicine, and low indicates someone who had just completed junior medical college or medical school. Pulmonologists' professional level was categorized into three levels: senior title implies deputy chief physician or chief physician, intermediate title implies attending physician, and junior title implies resident physician.

Inhalation corticosteroids/long-acting beta agonists, long-acting anticholinergic medications, and short-acting beta agonists were equipped in second- and third-level PHs. However, there was only salbutamol aerosol (short-acting beta agonist) in first-level PHs.

Allocation of COPD-related health care education

The overall availability ratio of COPD-related health care education in 2013 was 63%, and 22%, 63%, and 87% for the first-, second-, and third-level PHs, respectively. Significant differences were still considered among the availability rates of COPD-related health care education at different levels of PHs in 2013 ($\chi^2=9.96$, $P=0.006$), but no difference was found between the second- and third-level PHs ($\chi^2=2.66$, $P=0.10$). COPD-related health care education had been increasingly available from 2009 to 2013 ($\chi^2=4.17$, $P=0.04$) (Table 2).

Pulmonologists' basic knowledge of COPD

Score distribution of pulmonologists' questionnaire about COPD knowledge

In 2009, the total median score of the pulmonologists' questionnaire about COPD knowledge was 80, and 25, 80,

and 90 for the first-, second-, and third-level PHs, respectively. In 2013, the total median score was 70 and 40, 60, and 90 for the first-, second-, and third-level PHs, respectively. The total median score declined from 80 in 2009 to 70 in 2013, and it declined from 80 to 60 at second-level PHs ($P<0.001$). While pulmonologists' median score at first-level PHs increased from 25 in 2009 to 40 in 2013 ($U=621.50$, $P<0.001$), there was no change at third-level PHs between the years 2009 and 2013 ($P=0.634$).

Accuracy rate of every question of physicians

There was a clear difference in the accuracy rate (AR) of physicians at the three levels of PHs. AR was much better in the third-level PHs than in the first- and second-level PHs. The chi-squared test was used to calculate the difference in AR among different groups. Except for question four, which showed no difference between first- and second-level PHs ($P>0.05$), AR of the rest of the nine questions showed significant differences among the pulmonologists at all the three levels (Table 3).

In general, the higher the level of PHs the better was the pulmonologists' basic knowledge of COPD. Compared with

Table 2 Allocation of COPD-related health resources in three levels of public hospitals (PHs) in 2009 and 2013

Allocation of resources (%)	Total		Third-level PHs		Second-level PHs		First-level PHs	
	2009	2013	2009	2013	2009	2013	2009	2013
	(n=57)	(n=48)	(n=15)	(n=15)	(n=24)	(n=24)	(n=18)	(n=9)
Spirometers	40	69*	100	100	33	75*	0	0
Inhalation agents	58	88*	100	100	71	100*	6	33
COPD-related health care education	35	63*	67	87	42	63	0	22

Notes: *Chi-square test was used to compare in 2009 and 2013, $P<0.05$.

Table 3 Accuracy rate (AR) of every question of physicians in three levels of public hospitals (PHs) in 2013

Questionnaire	AR (%)		
	Third-level PHs (n=204)	Second-level PHs (n=506)	First-level PHs (n=52)
1. Hallmark symptom of COPD	86*	55*	40*
2. Pathogen of COPD	97*	83*	65*
3. Criteria of airflow limitation	91*	48*	21*
4. Diagnostic tools of COPD	100*	47*	40
5. Grading criteria of COPD	83*	43*	23*
6. Medicine of COPD	91*	65*	27*
7. Oxygen therapy of COPD	81*	51*	31*
8. Treatment of COPD	90*	66*	29*
9. Acute exacerbation cause of COPD	98*	93*	79*
10. Indication of noninvasive venation	83*	56*	40*

Notes: *Chi-square test was used to compare between any of the two groups, $P < 0.05$.

2009, there was no improvement in the pulmonologists' basic knowledge of COPD in 2013 ($P > 0.5$).

Comparison of scores based on educational levels of different pulmonologists in 2013

Among the total 762 pulmonologists, there were 133, 520, and 109 pulmonologists with low, medium, and high educational level, respectively, with a corresponding median score of 100, 70, and 40. The Kruskal–Wallis H -test was used to analyze the pulmonologists' scores among different groups. Higher educational level of the pulmonologist corresponded with a higher score on the COPD knowledge questionnaire ($P < 0.001$) (Figure 1).

Comparison of scores based on professional titles of different pulmonologists in 2013

Among the total 762 pulmonologists, there were 124, 332, and 306 pulmonologists with senior, intermediate, and junior title, respectively, with a corresponding median score of 90, 70, and 60. The Kruskal–Wallis H -test was used to analyze the pulmonologists' scores among different groups. The higher the professional title of the pulmonologist, the

higher was the score on the COPD knowledge questionnaire ($P < 0.001$) (Figure 2).

Above all, pulmonologists' understanding of COPD was associated with hospital level, educational background, and professional title. Spearman's rank correlation was used to calculate correlation analysis ($r_1 = 0.693$, $r_2 = 0.630$, $r_3 = 0.469$; $P < 0.001$).

Effect of short-term training combined with spirometry equipment on COPD diagnosis among the second-level hospitals 4 years after intervention

Pulmonologists' basic knowledge of COPD from six second-level PHs in 2013

In total, 204 questionnaires were sent to pulmonologists (78 pulmonologists in the intervention group and 126 in the control group) in six PHs, which took part in the further study, with a recovery rate of 100%. The median score of the intervention group was 80, and that of the control group was 50 ($P < 0.001$). Significant differences between the control group and the intervention group were observed among

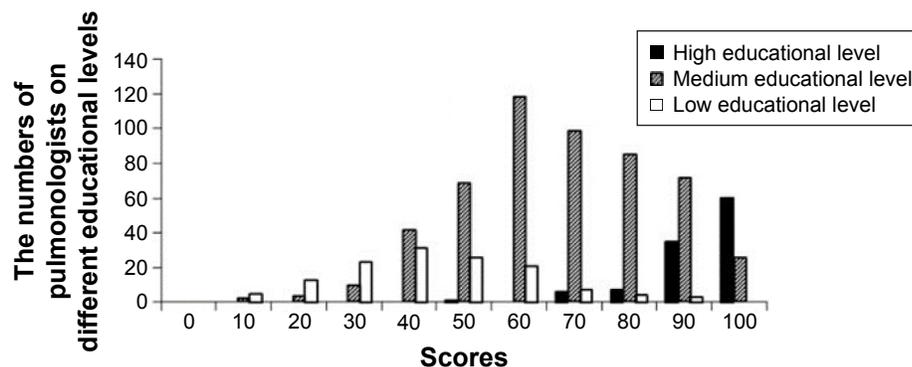


Figure 1 Scores of COPD knowledge questionnaire based on educational levels of different pulmonologists in 2013.

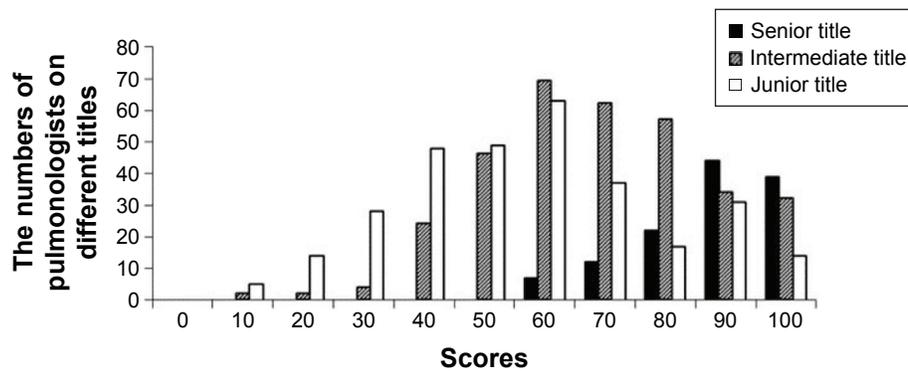


Figure 2 Scores of COPD knowledge questionnaire based on professional titles of different pulmonologists in 2013.

the median scores and AR (except question nine) in 2013 ($P < 0.05$) (Table 4).

Comparison of pulmonologists' clinical doubtful diagnostic ratio and diagnosis ratio of COPD between the two groups during the three periods

All of the hospitalized patients in our study were over the age of 40 years. During the period before intervention, there was no significant difference in the clinical doubtful diagnosis and diagnosis ratio of COPD between the control and the intervention groups. However, significant difference was found between the two groups during the intervention and follow-up visit ($P < 0.001$) (Table 5).

Discussion

Based on continuous renewal of Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines, combined with the national conditions, the Chinese Society of pulmonologists formulated and updated the diagnosis and treatment

guidelines for COPD, including definition, pathology and physiology, clinical manifestations, diagnosis, treatment, prevention, and other aspects of COPD.¹² These guidelines made it easier for the Chinese pulmonologists to diagnose and treat COPD accurately and effectively. Even so, the COPD-related health resources allocation, including the spirometry equipment, inhalation agents, COPD patient education, and even the pulmonologists' knowledge of COPD, are extremely imbalanced among the different levels of PHs in the People's Republic of China.

Spirometry is a safe, practical, and reproducible maximum breathing test that can be recommended as a "gold standard" to diagnose COPD and measure the severity of airflow obstruction.¹³ With the use of a spirometer, the diagnosis rate of COPD was doubled.¹⁴ Unfortunately, the allocation of spirometer resources is still imbalanced in South Central China, according to our study. At the third-level PHs, the spirometer equipment was sufficient, whereas at the first-level PHs, there were no spirometers even in 2013. For the second-level PHs,

Table 4 Accuracy rate (AR) of every question of physicians between the control group and the intervention group in six second-level PHs

Questionnaire	AR (%)		P-value
	Control group (n=126)	Intervention group (n=78)	
1. Hallmark symptom of COPD	60	94	<0.001*
2. Pathogen of COPD	62	90	<0.001*
3. Criteria of airflow limitation	41	63	0.002*
4. Diagnostic tools of COPD	60	77	0.018*
5. Grading criteria of COPD	44	63	0.01*
6. Medicine of COPD	52	87	<0.001*
7. Oxygen therapy of COPD	40	62	0.002*
8. Treatment of COPD	57	88	<0.001*
9. Acute exacerbation cause of COPD	86	94	0.08
10. Indication of noninvasive venation	45	60	0.04*

Notes: *Chi-square test was used to compare between the control group and the intervention group, $P < 0.05$.

Abbreviation: PHs, public hospitals.

Table 5 Doubtful diagnosis and diagnosis ratio of COPD between the control group and the intervention group during three periods in six second-level PHs

Groups	Before intervention			During intervention			Follow-up visit		
	n	Doubtful diagnosis	Diagnosis	n	Doubtful diagnosis	Diagnosis	n	Doubtful diagnosis	Diagnosis
Control group	3,322	1%	0%	2,990	1%	0%	4,331	4%	1%
Intervention group	2,867	1%	0%	2,930	14%	3%	4,136	15%	3%
χ^2		0.43			404.02	86.95		303.44	79.50
P-value		0.51			<0.001	<0.001		<0.001	<0.001

Abbreviation: PHs, public hospitals.

compared with the spirometer-equipped ratio in 2009, the ratio had risen in 2013. Lack of spirometry equipment may lead to underdiagnosis and misdiagnosis of COPD, which may explain the reason for a low diagnosis ratio of COPD in the People's Republic of China. Moreover, physicians who failed to realize the importance of spirometry in COPD management are mainly responsible for this condition.¹⁵

Inhalation treatment was preferred for COPD patients.¹² Our investigation showed that the total inhalation agent-equipped ratio increased in 2013, especially for the second-level PHs. The increase indicates that more patients can receive inhaled treatment for COPD. However, further study showed that some of the second- and all of the first-level PHs were only equipped with salbutamol aerosol, which is inadequate for COPD treatment. Even though the Chinese government has made a great effort to make health care service more accessible and affordable to every person, cost is an important obstacle to the universality of inhaled medicine. In the People's Republic of China, most COPD patients are in rural areas and are economically disadvantaged.¹⁶ In addition, age is another obstruction for the use of inhalers. Patients with COPD are generally elderly, and most elderly patients experience difficulties in achieving correct inhaler technique to gain optimum benefit from their inhaler even when in a stable clinical condition.^{17,18}

Health education plays an important role in the whole process of COPD, including the diagnosis, treatment, and management of COPD. COPD-related health education can improve disease management skills, inhaler adherence, and patients' lifestyle choices, and decrease COPD-related emergency room visits and hospital admissions. Importantly, COPD-related health education positively influenced health-related quality of life.^{19,20} Our study found that the overall availability rate of COPD-related health care education had increased dramatically in 2013 compared with 2009, which means that more COPD patients were able to receive COPD-related education. The low availability of COPD-related health care education was due to the following reasons: 1) currently, the management

of COPD patients has not been carried out effectively because of limited professional knowledge and a shortage of labor and funding.²¹ 2) Although most doctors know health education is important for COPD patients, many do not educate patients because they are busy treating patients.²² 3) Some patients cannot understand the contents of health education because of illiteracy, which is independently associated with poor health status.²³ Overall, popularity of COPD-related health education demands the coordinate efforts of medical institutions, hospitals, medical workers, and the general public.

Pulmonologists' expertise and awareness of COPD guidelines are vital to the accurate diagnosis of COPD.²⁴ The Chinese guidelines for the diagnosis and treatment of COPD have been revised and improved constantly over the past 2 decades.¹² However, implementation of these guidelines has been difficult, particularly in lower-level hospitals and rural areas. It was the same observance in our study: the total median score of the COPD knowledge questionnaire was even lower in 2013 than in 2009. In a further study, we had found the change of total score of the COPD knowledge questionnaire among groups was due to the proportion of the second-level PHs, which was a high proportion of the three levels PHs in our study, with lower total scores than in 2009. The study also showed that physicians' understanding of COPD was associated with hospital level, educational background, and professional title. In recent years, many second-level PHs underwent rapid expansion and had set up many new departments. Many of the expert clinicians were assigned to other departments, and the new respiratory clinicians were unfamiliar with COPD. This may be the main reason for low scores in the second-level PHs. Wilson et al discovered that persons with higher level of education possessed higher level of cognition, which may be the reason why those with higher educational level accept more new knowledge about COPD.²⁵ In higher level PHs, pulmonologists had more chances to gain knowledge about COPD and study further: for example, by studying abroad, joining international or domestic academic exchanges, and continuing medicine education. By contrast,

in lower-level PHs, shortage of staff, limitation of academic discipline, and insufficient funds hindered the burgeoning of continuing medical education, which lead to less knowledge about COPD for pulmonologists in these hospitals.^{26,27} Therefore, there is an urgent need for the pulmonologists and administrators to work together to improve knowledge about COPD. There are many interventions to improve physician application of knowledge, such as the use of multimedia, multiple instructional techniques, and multiple exposures.²⁸ Ahmed et al analyzed 28 studies by the Johns Hopkins Evidence-based Practice Center and discovered that most demonstrated an improvement in knowledge after face-to-face learning from specialists.²⁹ Moreover, hands-on skill training showed great improvement in clinician skills.³⁰ In the People's Republic of China, conductance of seminars in higher level PHs is a main method to enhance clinical skills. With the rapid development of the Internet and media, more network consultation systems are being carried out, and telemedicine is frequently used to deliver health care from a distance. Even so, challenges remain in the implementation of telemedicine in developing countries with immature systems as well as financial, health infrastructure, and legal and privacy issues.³¹ In our study, we found that with short-time face-to-face education classes combined with spirometry equipment, pulmonologists' knowledge and diagnosis ability of COPD increased significantly and persisted for 4 years. This simple and effective method should be generalized at different levels of PHs, especially PHs without spirometry equipment in the People's Republic of China. More mature systems for further medical study need to be developed.

Our study has limitations. Only 48 PHs were investigated in 2013 compared with 57 PHs in 2009. Nine first-level PHs could not be included because of changing hospital levels and incomplete data, which may influence the evaluation of the hospital at this level. When calculating the effect of short-time training, we could not investigate the same physicians in the control group for before-and-after comparisons because of anonymity.

Several study strengths are worth noting. The numbers of investigated PHs and pulmonologists are sufficiently high. The PHs are at different levels and thus are representative of all of the PH levels in Hunan Province. The study reveals that the allocation of COPD-related health care resources has improved over time. It provides a frame of reference to our health administrators and policy-makers to manage health resources. Our short training program is simple and can be made available at many hospitals. It is persistently effective over time.

Conclusion

Although extreme imbalance and disparity still exist in COPD-related health resources allocation, such as spirometry equipment, inhaled agent availability, and COPD-related health care education, at three levels of PHs in South Central China, the situation has improved in the 4 years since the intervention began. Unfortunately, physicians' understanding of COPD declined, especially in the second-level PHs. The understanding was found to be associated with hospital level, educational background, and professional title. Overall, short-term training combined with spirometry equipment had a sustained effect on improving the physicians' understanding and diagnosis ability of COPD.

Acknowledgments

This study was supported by the Chronic Respiratory Disease Funds of the Chinese Medical Association (07010310039) and the National Key Clinical Specialty Construction Projects. We express thanks to all the physicians and patients who took part in this study.

Disclosure

The authors report no conflicts of interest in this work.

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