


# Potential Factors of Primary Hospital Healthcare Professionals in Hindering the Abolition of Routine Skin Test for Cephalosporin: A Cross-Sectional Study

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**Background:** In 2021, National Health Commission of the People's Republic of Chinese issued a document that no longer recommended the routine skin test for cephalosporin (RSTC). However, there is still resistance to the cancellation of RSTC in a primary hospital. The study aimed to explore the potential factors for hindering the abolition of the RSTC in a county-level hospital based on the PRECEDE model.

**Methods:** The cross-sectional study was conducted on healthcare workers in the Pidu District People's Hospital, Chengdu, by online questionnaire from September 10 to September 25 in the 2021. The PRECEDE model was used to divide the potential factors of healthcare professionals in hindering the abolition of the RSTC into predisposing factors, enabling factors and reinforcing factors. Data were analyzed by ANOVA, Chi-square test, multiple linear and multiple logistic regression analysis.

**Results:** We collected 605 respondents' valid questionnaires. 254 healthcare professionals were against cancellation of the RSTC, accounting for 41.98%. Multiple linear regression analysis showed that working for 6~10 years ( $\beta = 1.953$ ,  $P = 0.024$ ), medium ( $\beta = 1.995$ ,  $P = 0.030$ ) or senior ( $\beta = 4.003$ ,  $P = 0.007$ ) professional qualification, pharmacists ( $\beta = 3.830$ ,  $P = 0.013$ ) and working in surgical department ( $\beta = 4.462$ ,  $P < 0.001$ ) were significantly associated with higher score of predisposing factors, enabling factors, and reinforcing factors on abolition of RSTC. Furthermore, multiple logistic regression analysis showed that pharmacists (OR=3.113, 95% CI: 1.341–7.223,  $P=0.030$ ), medium professional qualification (OR=1.272, 95% CI: 0.702–2.302,  $P=0.008$ ), scores of predisposing factors (OR=1.335, 95% CI: 1.033–1.726,  $P=0.009$ ), and scores of enabling factors (OR=1.208, 95% CI: 1.109–1.315,  $P<0.001$ ) were independently associated with the positive anticipated behavior on the abolition of RSTC. While nurses (OR=0.516, 95% CI: 0.284–0.938,  $P<0.001$ ) were independently associated with anticipated negative behavior.

**Conclusion:** Pharmacists, medium professional qualification, and healthcare professionals with higher scores of predisposing and enabling factors were more likely to have a positive anticipated behavior on the abolition of RSTC, while nurses did not.

**Keywords:** cephalosporin, skin test, potential factors, PRECEDE model, cross-sectional study

## Introduction

The antibacterial agents of the cephalosporin class ("cephalosporins") are characterized by a wide antibacterial spectrum, strong antibacterial action, and satisfactory safety.<sup>1</sup> Therefore, cephalosporin is widely used for clinical purposes. The major adverse reaction of cephalosporin is an allergic reaction, which accounts for an occurrence rate of 0.07%–2.8%.<sup>2,3</sup> For example, cefuroxime causes facial and palmar erythema, sweating, shortness of breath, upper limb urticaria,

hoarseness, tachycardia (a selective systemic anaphylaxis attributable to cefuroxime).<sup>4</sup> Cefepime causes generalized pruritus and urticaria, with dyspnea and wheezing.<sup>5</sup> Serious allergic shock due to cephalosporin is very rare, with rates of 0.0001%-0.1%,<sup>2,3</sup> and some deaths were even reported in extreme cases.<sup>6-8</sup>

Due to their increasing use in hospitals, the number of reports concerning the adverse reaction of cephalosporin has also been increasing. Therefore, in most hospitals in China, especially primary hospitals where medical and pharmaceutical professional skill level are relatively low and training is relatively less, a routine skin test would be carried out before cephalosporin is administered, but whether the routine skin test is required before the use of cephalosporin is controversial.<sup>9,10</sup> Because the metabolites of cephalosporins still cannot be identified clearly and no special-purpose reagents for the skin test are currently available, the sensitivity, specificity, and positive predictive value of the cephalosporin skin test are uncertain.<sup>9,10</sup> In addition, the predictive value of the routine skin test for cephalosporin (RSTC) for immediate allergic reactions is not available.<sup>11</sup> Furthermore, the RSTC can evoke an allergic reaction. At present, no RSTC is required before cephalosporin treatment in the United States of America (USA) and Europe.<sup>12-14</sup> More and more experts and scholars in China are questioning the necessity, and predictive value of the RSTC and are advocating that the RSTC should be abolished. The RSTC is not evidence-based and is not required by any Chinese or international regulatory documents and technical guidelines. Abolishing the RSTC should not only save human and material resources but also help the healthcare workers cultivate an evidence-based thinking pattern and could facilitate the rational use of cephalosporin.

In 2021, the General Office of the National Health Commission promulgated the Guiding Principles for the Skin Test of Beta-lactam Antibiotics (2021), which further standardizes the use and judgment of the skin test for  $\beta$ -lactam antibiotics, and clearly states that a routine skin test before cephalosporin is not recommended. However, most hospitals, especially grass-root hospitals, are still using the skin test and have not taken concrete steps to abolish it. The author conducted a preliminary investigation in the hospital where he worked. The results showed that most healthcare workers did not support the idea of abolishing the RSTC. Studies on the understanding and beliefs of and actions taken by healthcare workers in abolishing the RSTC are very rare. In addition, the author failed to find any study on the influencing factors that would hinder the practice of abolishing the RSTC.

PRECEDE-PROCEED is a model of health education and promotion, proposed by Green, Kreuter etc (1980) and improved gradually.<sup>15,16</sup> PRECEDE (Educational Diagnosis) is the core of the PRECEDE-PROCEED model, which stands for Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation and is a comprehensive structure for assessing health needs and medical issues.<sup>15,17,18</sup> The PRECEDE model provides a comprehensive structure for designing, implementing, and evaluating health promotion and other public health programs to meet those needs. It guides planners through a process that starts with desired outcomes and then works backward in the causal chain to identify a mix of strategies for achieving those objectives.<sup>17,18</sup> Measuring the predisposing factors, enabling factors, and reinforcing factors based on the PRECEDE model of healthcare professionals can be very valuable for the proper planning of intervention measures. Considering the importance of this issue, the study aimed to explore the potential factors for hindering the abolition of the RSTC in a county-level hospital based on the PRECEDE model.

## Materials and Methods

### Study Design and Participants

This cross-sectional study was conducted on the healthcare workers, including doctors, nurses, and pharmacists, at the Pidou District People's Hospital, Chengdu, Sichuan, China. The questionnaire was designed based the PRECEDE model, which divided the potential factors of healthcare professionals in hindering the abolition of the RSTC into predisposing factors, enabling factors, and reinforcing factors. Questionnaire and information were collected via an online platform from September 10th to 25th in 2021.

Inclusion criteria: doctors, pharmacists and nurses with > 1 years of working experience in Pidou District People's Hospital, Chengdu, Sichuan, China.

## Outcome Measurement and Data Collection

In PRECEDE model, the predisposing, enabling, and reinforcing factors in behavior are determined. The knowledge, attitude, and practice of healthcare workers on hindering the abolition of the RSTC were summarized as follows based on the PROCEDE-PROCEED and PRECEDE models.<sup>17,18</sup> (1) Predisposing factors mainly included knowledge, attitude, ideals, and value concepts, which revealed the understanding and grasping of the relevant policies and knowledge of the RSTC, as well as the attitude towards abolishing the skin test in healthcare workers. The “knowledge” part contained five questions (Q1-Q5). The total score was 0–5 points. The “Attitude” part contained four questions (Q6-Q9), and the total score was 4–20 points. (2) Enabling factors, which revealed the objective factors of behavior implementation, including the medical treatment environment and attention. This part contained four questions (Q10-Q13) and the total score was 4–20 points. (3) Reinforcement factors include knowledge and skills training from senior medical or pharmaceutical experts, in-hospital supervision and management, and knowledge dissemination. This part contained four questions (Q14-Q17) and the total score was 4–20 points. The Likert Scale method (1–5 points) was adopted for Q6-Q17. More information was provided in [Supplementary Table 1](#).

The questionnaire was adopted and the project was carried out through [www.wjx.cn](http://www.wjx.cn), an online platform for questionnaire surveys. The questionnaires were filled in an anonymous manner. The overall Cronbach's  $\alpha$  coefficient of the questionnaire was 0.790, the tendency factor was 0.613, the contributing factor was 0.950, and the strengthening factor was 0.795, indicating that the reliability of the questionnaire was satisfactory. The empirical factor analysis showed that the model CFI (Comparative Fit Index) was 0.937, TLI (Tucker-Lewis Index) was 0.927, and the root mean square error of estimation (RMSEA) was 0.066, indicating that the construct validity of the questionnaire was high.

## Ethical Considerations

This study complies with the guidelines for human studies and is in accordance with the Declaration of Helsinki. This study was approved by the Ethics Committee of the Pidu District People's Hospital, Chengdu (code of ethics: [2021] 237). The investigation has been fully informed in the whole hospital and department, and the questionnaire information will only be used for research. The research is anonymous and does not include personal privacy, thus we obtained an informed immunity from the Ethics Committee of the Pidu District People's Hospital, Chengdu.

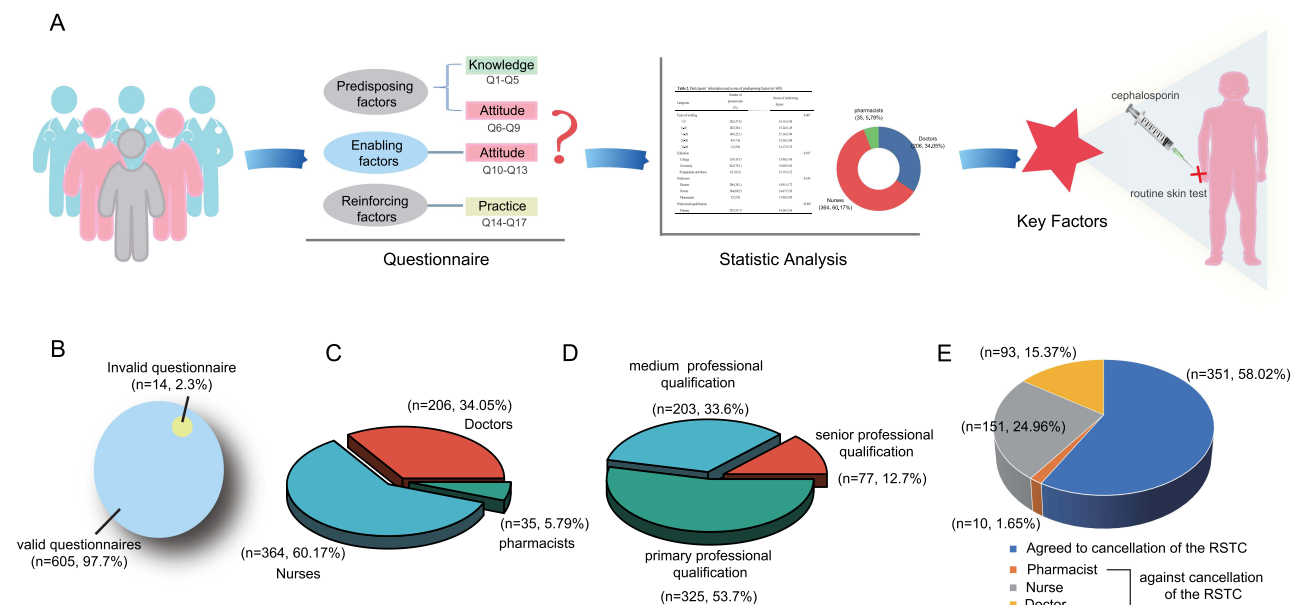
## Statistical Analysis

SPSS 23.0 (IBM, Armonk, NY, USA) was used for the analysis. Continuous data were expressed as mean  $\pm$  standard deviation (SD) and compared by ANOVA. Categorical data were expressed as n (%) and compared by the Chi-square test. Multiple linear regression analysis was used to analyze the propensity score of RSTC. Multiple logistic regression analysis was used to analyze the propensity score of RSTC. Two-sided P-values < 0.05 were considered statistically significant.

## Results

### Procedure and Participants

The study was conducted according to the procedure in [Figure 1A](#). 619 questionnaires were collected and 605 were valid questionnaires. The validity rate was 97.7% ([Figure 1B](#)). The respondents included 206 (34.05%) doctors, 364 (60.17%) nurses and 35 (5.79%) pharmacists ([Figure 1C](#)). 77 respondents (12.7%) had senior professional qualification, which including chief (deputy director) physician, chief (deputy director) pharmacist, chief (deputy director) technician, chief (deputy director) nurse. 203 respondents (33.6%) had medium professional qualification, including attending physician, pharmacist in charge, nurse in charge, clinical laboratory technician in charge. 325 respondents (53.7%) had primary professional qualification, including physician, pharmacist, nurse, clinical laboratory technician. ([Figure 1D](#)). Further study showed that 351 respondents agreed to cancel the skin test of cephalosporin routine, accounting for 58.02%. 254 respondents who disagreed with the cancellation of routine skin test of cephalospora, accounting for 41.98%, including 10 pharmacists, 151 nurses, and 93 doctors ([Figure 1E](#)).



**Table 1** Participants' Information and Scores of Predisposing Factors (n=605)

Categories	Number of Persons/Ratio (%)	Scores of Predisposing Factors		Scores of Enabling Factors (Attitude)	Scores of Reinforcing Factors (Practice)
		Knowledge	Attitude		
Sex					
Male	123 (20.3)	2.63±1.09	14.41±2.07	15.92±4.42	14.93±4.14
Female	482 (79.7)	2.24±0.99	14.44±2.01	15.93±3.87	14.79±3.44
P		<0.001	0.894	0.970	0.707
Age					
21–30	268 (44.3)	2.18±1.00	14.42±2.06	15.58±3.78	14.38±3.31
31–40	253 (41.8)	2.36±0.99	14.42±2.08	16.06±4.27	15.06±3.96
41–50	66 (10.9)	2.59±1.08	14.42±1.62	16.53±3.75	15.48±3.09
51–60	18 (3.0)	2.83±1.25	15.00±2.00	17.06±3.33	15.50±3.33
P		0.002	0.697	0.153	0.042
Working years					
≤5	226 (37.4)	2.22±0.95	14.18±2.04	15.25±4.02	14.15±3.50
6–10	182 (30.1)	2.23±1.05	14.75±2.10	16.20±3.70	15.24±3.45
11–20	140 (23.1)	2.52±1.04	14.46±1.93	16.53±4.22	15.16±3.99
21–30	45 (7.4)	2.33±1.02	14.33±1.77	16.36±3.86	15.58±2.90
31–40	12 (2.0)	3.25±1.06	14.75±2.09	16.00±3.88	14.17±3.33
P		<0.001	0.076	0.025	0.007
Education					
College	119 (19.7)	2.14±0.96	14.24±2.13	15.43±3.94	13.98±3.45
University	424 (70.1)	2.33±1.00	14.56±1.97	16.05±3.95	15.00±3.62
Postgraduate and above	62 (10.3)	2.60±1.26	13.94±2.10	16.05±4.27	15.15±3.52
P		0.017	0.037	0.308	0.017
Profession					
Doctors	206 (34.1)	2.58±1.04	14.40±1.93	15.43±4.36	14.91±3.72
Nurses	364 (60.2)	2.10±0.93	14.49±2.11	16.10±3.82	14.67±3.56
Pharmacists	35 (5.8)	3.14±1.12	14.09±1.58	17.11±3.00	15.80±3.05
P		<0.001	0.498	0.029	0.185
Professional qualification					
Primary	325 (53.7)	2.13±0.98	14.42±2.09	15.50±3.97	14.28±3.56
Medium	203 (33.6)	2.41±0.97	14.46±2.01	16.34±3.95	15.38±3.51
Senior	77 (12.7)	2.90±1.08	14.45±1.82	16.68±3.95	15.60±3.61
P		<0.001	0.962	0.013	<0.001
Department					
Surgical	222 (36.7)	2.18±0.97	14.46±2.09	15.80±4.17	14.67±3.75
Non-surgical	383 (63.3)	2.40±1.05	14.42±1.99	16.01±3.87	14.90±3.50
P		0.012	0.798	0.545	0.443
Infection/respiratory	48 (7.9)	2.38±0.94	14.94±1.62	17.83±2.87	16.25±2.69
None infection/respiratory	557 (92.1)	2.32±1.02	14.39±2.05	15.77±4.03	14.69±3.63
P		0.702	0.073	<0.001	0.003

qualification, were pharmacists ( $\beta=3.830$ ,  $P=0.013$ ), and worked in surgical department ( $\beta=4.462$ ,  $P<0.001$ ) were significantly associated with predisposing factors, enabling factors and reinforcing factors on abolition of RSTC (Table 2).

## Multiple Logistic Regression Analysis of the Prospective Behavior of Routine Skin Test for Cephalosporin

Whether a routine skin test is required before the use of cephalosporins is taken as the dependent variable, and gender, age, years of work, highest education, profession, professional qualification and department, predisposing factors (knowledge and attitude), enabling factors and reinforcing factors are taken as independent variables. The qualitative factors are in the form of dummy variables. Multiple logistic regression model was conducted and stepwise regression analysis was used for factor screening. The results showed that pharmacists (OR=3.113, 95% CI: 1.341–7.223,  $P=0.030$ ),

**Table 2** Multiple Linear Regression Analysis for Score of Predisposing Factors, Enabling Factors, and Reinforcing Factors on Abolition of Routine Skin Test for Cephalosporin

Variables	Coefficient	Standard Error	t	P
Years of working				
≤5	Ref.			
6–10	1.953	0.861	2.267	0.024
11–20	0.953	1.117	0.853	0.394
21–30	0.236	1.562	0.151	0.880
31–40	−0.938	2.675	−0.351	0.726
Profession				
Doctors	Ref.			
Pharmacists	3.830	1.532	2.501	0.013
Nurses	1.355	0.786	1.725	0.085
Professional qualification				
Primary	Ref.			
Medium	4.003	1.480	2.705	0.007
Senior	1.995	0.918	2.172	0.030
Department				
None infection/respiratory	Ref.			
Surgical	4.462	1.242	3.594	<0.001
Infection/respiratory	0.257	0.705	0.365	0.716

**Table 3** Multiple Logistic Regression Analysis for Anticipated Behavior on Abolition of Routine Skin Test for Cephalosporin

Variables	OR	95% CI	P
Profession			
Doctors			
Nurses	0.516	0.284–0.938	<0.001
Pharmacists	3.113	1.341–7.223	0.030
Professional qualification			
Primary			
Medium	1.272	0.702–2.302	0.008
Senior	2.643	1.263–5.531	0.427
Scores of predisposing factors (Knowledge)	1.335	1.033–1.726	0.009
Scores of enabling factors (Attitude)	1.208	1.109–1.315	<0.001

medium professional qualification (OR=1.272, 95% CI: 0.702–2.302, P=0.008), high scores of predisposing factors (OR=1.335, 95% CI: 1.033–1.726, P=0.009), and high scores of enabling factors (OR=1.208, 95% CI: 1.109–1.315, P<0.001) were independently associated with the positive anticipated behavior on the abolition of RSTC. While nurses (OR=0.516, 95% CI: 0.284–0.938, P<0.001) were independently associated with anticipated negative behavior (Table 3).

## Discussion

PRECEDE-PROCEED is a model of health education and promotion, proposed by Green, Kreuter, Deeds and Partridge (1980) and the core of the PRECEDE-PROCEED model is PRECEDE (Educational Diagnosis).<sup>15,16</sup> In recent years, this model has been widely used in the assessment of practice or intervention of health behavior, as well as health promotion activities such as hygiene and healthcare.<sup>18–20</sup> Till now, studies on implementing this model in the relevant fields of pharmacy are very rare. This study is the first to analyze the related factors that hinder the practice of a county-level hospital in abolishing the RSTC based on the PRECEDE model. According to the Chinese medical hierarchy, the hospital studied is a Grade-3 and Class-A comprehensive hospital, which confers the highest level.

Predisposing factors stand for the motives and expectations of certain behaviors, which mainly include knowledge, attitude, ideals and value concepts.<sup>15</sup> The results showed that in terms of knowledge related to the RSTC, the score of female healthcare workers was generally lower than that of male. Further investigation showed that the low score of female healthcare workers was mainly nurses, which revealed that hospitals should focus on strengthening the training and evaluation of the nurses on the relevant knowledge of skin tests. In addition, the results also showed that respondents in older age, with high educational backgrounds or high professional qualification tended to obtain higher score in the “Knowledge” part, which consistent with previous studies on the rationale use of antibiotics.<sup>21–23</sup> These factors suggest that knowledge about the cephalosporin skin test should be enforced early in the career of the healthcare workers. Pharmacists scored highest for knowledge of medicines, which is logical base on the content of their work. Similar results were observed for antimicrobial stewardship.<sup>21–23</sup> Furthermore, doctors order skin tests, while nurses are usually the ones who perform them, which leading to knowledge differences. Therefore, appropriate training should be conducted to doctors and nurses. In the “Knowledge” part, the scores of healthcare workers from non-surgical departments were higher than those of healthcare workers from surgical departments. Staff from surgical departments also should receive training.

In the “Attitude” part, the scores of healthcare workers with junior college and bachelor’s degree were almost the same, while the scores of healthcare workers with master’s degree or above were the lowest. Further analysis revealed that healthcare workers with master’s degree obtained the lowest score in “Q7 - Are you going to give up prescribing cephalosporin to the patients as a treatment preference because of the need for skin tests in advance?” It showed that healthcare workers with postgraduate education would not give up prescribing cephalosporin to patients as a treatment preference because of the need for skin tests in advance.

Enabling factors refer to the factors that affect the target behavior by acting on the environment.<sup>15</sup> Results showed that respondents with  $\leq 5$  years of working experience and low professional qualification obtained low score. Besides, the scores were significantly higher in infectious diseases/respiratory departments compared with non-infectious diseases/respiratory departments. In addition, the multivariable analysis showed that the highest scores were associated with higher experience, intermediate/senior professional qualification, pharmacists, and those working in a surgical department. Antibiotic prophylaxis is regularly given for several surgeries and healthcare workers in surgical departments are more likely to have more experience with antibiotics in general.<sup>24,25</sup> The analysis of Q10-Q13 revealed that on the issue of RSTC abolition, the relevant government policy and the recommendations of professional academic bodies have been relatively influential among medical workers with longer working years, medical workers with intermediate or senior professional qualifications, and medical workers in infectious diseases or respiratory related departments. In addition, the investigation results of this study also revealed that in terms of the enabling factors, doctors scored the lowest, followed by nurses, and pharmacists scored the highest, as supported by previous studies on antibiotics use.<sup>21–23</sup> Thus, it is necessary to further strengthen the healthcare workers’ recognition of the abolishing of the RSTC. While offering training programs, the hospital should place stress on doctors and nurses, especially young doctors and nurses with fewer years of work.

Reinforcing factors stand for the factors that would facilitate the continual progression of the target behaviors.<sup>15</sup> The results showed that as far as the reinforcing factors were concerned, the lowest scores were observed in the 20–30 age group, which indicated that younger healthcare workers would be less influenced by the reinforcing factors including the promotion or training programs. In addition, healthcare workers with working life  $\leq 5$  years and working life between 31 and 40 years also had relatively low scores of the reinforcing factors, indicating that in the practice of cancellation of cephalosporin routine skin test in the later stage, attention should be paid to the strengthening of relevant knowledge training for healthcare workers, but also to the positive incentives for senior healthcare workers. Healthcare workers with higher educational backgrounds and professional qualifications, as well as healthcare workers from the relevant departments of infectious diseases or respiration, scored relatively higher as the reinforcing factors were concerned, suggesting that the reinforcing factors were relatively more influential among healthcare workers with higher educational backgrounds, professional qualifications and healthcare workers from the relevant departments of infectious diseases.

This cross-sectional study on the influence factors that affect the practice of a county-level hospital in abolishing the RSTC in a Grade 3 Class A comprehensive hospital showed that the largest obstacle to the practice of grass-root hospitals in abolishing the RSTC was the likelihood that without the skin test, healthcare workers would have to undertake more responsibilities in case of a medical dispute. Hospital managers and management departments should take active actions

and implement accurate and precise interventions in combination with the above three influencing factors to help doctors and nurses eliminate their concerns and doubts. The results showed that pharmacists realized the knowledge of cephalosporin skin test better than doctors and nurses. In addition, the scores of enabling factors was also higher than those of doctors and nurses, revealing that if supported by relevant policies and regulations, pharmacists would be more willing to actively practice and promote the cancellation of routine cephalosporin skin test. The proportion of pharmacists in medical institutions in China is relatively low. According to China's Regulations on the Administration of Pharmaceutical Affairs in Medical institutions, pharmacists in medical institutions shall not be less than 8% of the health professionals. However, it is difficult for Chinese hospitals to meet this requirement. The results show that pharmacists will be the main force to promote the cancellation of cephalosporin routine skin tests. Therefore, pharmacists should actively play a professional advantage to promote the abolition of cephalosporin skin test. Pharmacists are expected to actively cooperate with the advancement of the practices mentioned in this research. The research was the first to investigate the influence factors that hinder the practice of healthcare workers of a county-level hospital in abolishing the RSTC by PRECEDE-PROCEED model. It provided a new sight of thinking pattern or method for further abolishing the RSTC. Therefore, the results of this research are valuable in guiding the practice of grass-root hospitals in abolishing the RSTC.

## Conclusion

Pharmacists, medium professional qualification, and healthcare professionals with higher scores of predisposing and enabling factors were more likely to have a positive anticipated behavior on the abolition of RSTC, while nurses were the opposite. The results could serve as a reference and guidance for healthcare professionals to advance the work of abolishing RSTCs and improving the rational use of antibacterial agents.

## Data Sharing Statement

[Supplementary Table](#) can be found within the article/[Supplementary Materials](#). Raw data can be provided through corresponding author.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no conflicts of interest in this work.

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