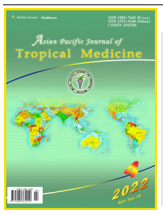

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Surveillance system-based physician reporting of pneumonia of unknown etiology in China: A cross-sectional study

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ABSTRACT

Objective: To describe the current reporting of pneumonia of unknown etiology (PUE) and factors that affect reporting by clinicians in China using the PUE surveillance system in order to provide a reference for improving PUE reporting rates in the future.

Methods: Clinicians were recruited *via* the Sojump platform and requested to complete an anonymous self-administered questionnaire. Multivariate logistic regression analysis was used to assess factors influencing clinicians' reporting activities.

Results: This study showed a low PUE case reporting rate and a poor understanding of PUE reporting among the investigated clinicians. Of the 136 clinicians who had diagnosed PUE cases, multivariate logistic regression analysis results showed that clinicians who had attended in-hospital training were more likely to report PUE than those who had not (*OR* 4.48, 95% *CI* 1.49-13.46). Clinicians with an expert panel on PUE in their hospital were more likely to report PUE cases than those without (*OR* 5.46, 95% *CI* 1.85-16.11).

Conclusions: There is a need to promote and reinforce PUE surveillance system training among medical staff. In addition, PUE testing technologies in hospital laboratories should be upgraded, especially in primary and unclassified hospitals, to increase surveillance efficiency and improve PUE reporting rates.

KEYWORDS: Pneumonia of unknown etiology; Surveillance; Reporting

1. Introduction

A severe respiratory disease of unknown origin emerged in Guangdong province in late 2002 and was confirmed to be severe acute respiratory syndrome (SARS) in March 2003[1], which became a serious public health issue in China. Initially, a clear understanding of the disease was lacking, and no effective measures were established in the early stage. Based on the experience and lessons learned from the SARS epidemic, the Chinese government identified crucial deficiencies in the public health system and decided to improve the infectious disease surveillance system[2]. Consequently, a surveillance system for pneumonia of unknown etiology (PUE) was established 1 year after the SARS outbreak in 2003[3]. The purpose of the system was to promptly detect unexplained respiratory infectious diseases characterized by pneumonia as the main clinical manifestation, and thereby help limit the spread of

Significance

Several studies have reported low pneumonia of unknown etiology (PUE) reporting rates in mainland China, but few have explored the factors influencing clinicians' likelihood to report PUE cases. This study provides a reference for improving the efficiency of PUE surveillance, thereby facilitating the management of potential emerging infectious diseases in China.

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emerging infectious diseases in their early stages. The surveillance system for PUE is separate from the nationwide direct reporting system for notifiable diseases, which does not manage emerging infectious diseases. The Ministry of Health first formulated the National Programme for Surveillance, Detection, and Management of PUE cases in 2007 and revised the program in 2013. The PUE surveillance system played a crucial role in H7N9 detection in 2013[4]. Six years later, coronavirus disease-2019 (COVID-19) emerged. The ongoing global COVID-19 pandemic has lasted more than 2 years and remains a critical threat to human life and health, demonstrating the importance of PUE surveillance for detecting wild animal-originating pathogens, such as SARS coronaviruses, middle east respiratory syndrome coronavirus, and Ebola[5].

However, issues with the PUE surveillance system remain to be addressed[4,6,7]. For example, although the number of patients meeting the PUE case definition in hospitals has been high, discrepancies between the actual case numbers and the number of reported cases have been observed[8,9]. In an analysis of PUE in China from 2004 to 2009, only 864 cases were reported; among them, 793 were eventually excluded and diagnosed as other diseases[8]. A study conducted from February 29 to May 29, 2016, revealed that 335 of 2619 acute respiratory infection admissions met the PUE case definition, but none were reported[9].

In general, studies have found low PUE case reporting rates, indicating that the system has not been sufficiently exploited to monitor PUE cases, including COVID-19 in 2019. Improvements are needed to optimize PUE case surveillance; however, a systematic survey of the entire identification process for PUE cases must first be conducted to identify the factors affecting PUE cases reporting. Undoubtedly, clinicians play an essential role in the monitoring of PUE cases. In this study, we surveyed the state of PUE cases reporting practices among clinicians from hospitals of different grades to describe the current status of reporting and identify the factors influencing clinicians' likelihood to report PUE cases. Our findings will provide a reference for improving the efficiency of PUE surveillance, thereby facilitating the management of potential emerging infectious diseases in the future.

2. Subjects and methods

2.1. Study design and population

We conducted a cross-sectional study in which online convenience sampling was performed from March 10 to 22, 2021. The participants were clinicians who specialized in general internal medicine, respiratory medicine, thoracic surgery, infection department, pediatrics, emergency medicine, critical care medicine, and cardiology. Clinicians were recruited from professional groups *via* the Sojump platform (www.sojump.com) and were requested to complete an anonymous self-administered questionnaire. The questionnaire began with a declaration that the survey was anonymous and no individual identifiers would appear in this study. The agreement was arranged before the online questionnaire; only participants who read the agreement and ticked "agree" could proceed to answer the questionnaire.

The sample size was estimated by using the sample size calculation formula for cross-sectional studies: $n=Z\alpha^2\times$proportion $(1-$proportion$)/$precision^2. In this equation, $\alpha=0.05$, $Z\alpha=1.96$, and the precision was 0.05. According to a previous study in China, the PUE case reporting rate by clinicians was 34.1%[10]. The calculated minimum sample size was 346 participants, and 990 questionnaires were filled out.

2.2. Questionnaires

The questionnaire consisted of three sections. The first section covered general demographic information (gender, age, education, and years of clinical work). The second section surveyed the clinician's recognition of PUE cases and included questions regarding the clinician's basis for diagnosing of PUE cases and case definition. The participants were also asked how they would deal with suspected PUE cases and whether they had diagnosed PUE cases. Finally, in the third portion of the questionnaire, the management of PUE case reporting was investigated. The participants were asked whether they were aware of the PUE surveillance system, whether they underwent training and emergency drills related to PUE, and whether they had reported PUE cases. For the final question, clinicians were asked, "What factors influence your reporting of PUE cases? ".

2.3. Explanation of terms and definitions

The National Programme for Surveillance, Identification, and Management of PUE cases (2013 version) requires reporting of PUE cases meeting all of the following criteria: (1) fever (axillary body temperature$\geqslant$38 ℃); (2) radiographic features of pneumonia; (3) reduced or normal total white blood cell count or reduced lymphocyte sorting count early in the course of the illness; and (4) pneumonia that cannot be clinically diagnosed or diagnosed in the laboratory because it was not caused by a common pathogen.

Hospital grades, which are indicators of China's assessment of hospital qualifications based on hospital size, research fields, talents and technical strength, medical hardware, and equipments, are unified across the country. Hospitals were assessed and categorized as tertiary, secondary, or primary.

In China, clinicians must obtain a technical title to practice. The titles of clinicians were classified in descending order as chief physician, associate chief physician, attending physician, and resident physician.

2.4. Statistical analysis

SPSS 22.0 software (SPSS, Inc.) was used for statistical analyses. The continuous variables, such as age and years of clinical work, were transformed into categorical variables, and the median values were used as the cutoff values. Categorical variables, such as sex, were described as percentages (%). Differences in categorical variables were compared between clinicians reporting and not reporting PUE cases using a *Chi*-square test or Fisher's exact test. All factors with $P<0.10$ in the univariate analysis were included in the multivariate logistic analysis. Differences were considered statistically significant at $P<0.05$.

2.5. Quality control

Before the formal investigation, we conducted a pre-survey of 58 clinicians and revised the questionnaire according to their opinions.

2.6. Institutional or ethics review board

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board of Sun Yat-sen University (approval code # L2021039).

3. Results

3.1. Sociodemographic characteristics

The clinicians surveyed were mainly from three provinces, namely, Shandong (60.1%, 594/989), Guangdong (14.2%, 140/989), and Hainan (8.8%, 87/989).

Nine hundred eighty-nine questionnaires were collected in the study. The median age of the participants was 37 years (range: 19-63 years), and the median duration of clinical work experience was 12 years (range: 0-45 years). The top three departments with the highest diagnosis rates for PUE cases were respiratory medicine (27.3%), critical care medicine (27.2%), and the infection department (21.1%). The top three departments with the highest reporting rates for PUE cases were the infection department (15.8%), respiratory medicine (15.7%), and critical care medicine (8.0%).

Among the 989 clinicians surveyed, 24.9% (246/989) had encountered suspected cases of PUE among their patients, and 55.3% (136/246) had made the final diagnosis of a PUE cases. However, only 50.7% (69/136) of those diagnoses had been reported PUE cases (Figure 1).

Significant differences in the clinicians' age, duration of clinical work, professional titles, and hospital grade were detected between those who had diagnosed PUE cases and those who had not. Clinicians aged >37 years were more likely to have diagnosed PUE

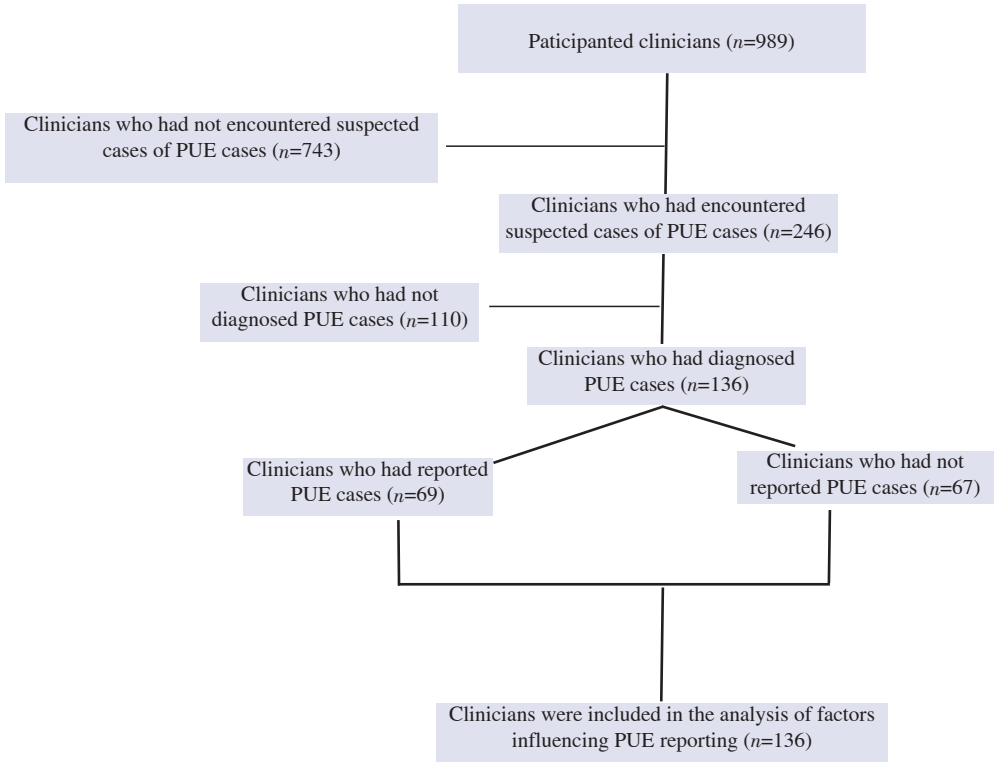

Figure 1. Flowchart of participants selection. PUE: pneumonia of unknown etiology. First, we analyzed data of 989 participants, then included 136 clinicians for multivariate logistic analysis to explore factors influencing clinicians' likelihood to report PUE cases.

Table 1. Sociodemographic characteristics and identification of pneumonia of unknown etiology cases among clinicians in China [*n*(%)].

Variables	Clinicians who diagnosed PUE (*n*=136)	Clinicians who reported PUE		*P*
		Yes (*n*=69)	No (*n*=67)	
Gender				0.391
Male	68 (50.0)	37 (53.6)	31 (46.3)	
Female	68 (50.0)	32 (46.4)	36 (53.7)	
Age, years				0.233
⩽37	52 (38.2)	23 (33.3)	29 (43.3)	
>37	84 (61.8)	46 (66.7)	38 (56.7)	
Years of clinical work				0.401
⩽12	56 (41.2)	26 (37.7)	30 (44.8)	
>12	80 (58.8)	43 (62.3)	37 (55.2)	
Title of clinician				0.335
Resident doctor	28 (20.6)	17 (24.6)	11 (16.4)	
Attending doctor	44 (32.4)	20 (29.0)	24 (35.8)	
Associate chief physician	43 (31.6)	19 (27.5)	24 (35.8)	
Chief physician	21 (15.4)	13 (18.8)	8 (11.9)	
Speciality				0.006*
General internal medicine	29 (21.3)	19 (27.5)	10 (14.9)	
Respiratory medicine	47 (34.6)	27 (39.1)	20 (29.9)	
Infection department	12 (8.8)	9 (13.0)	3 (4.5)	
Pediatrics	5 (3.7)	2 (2.9)	3 (4.5)	
Emergency medicine	5 (3.7)	2 (2.9)	3 (4.5)	
Critical care medicine	34 (25.0)	10 (14.6)	24 (35.8)	
Cardiology	4 (2.9)	0 (0.0)	4 (6.0)	
Hospital grade				0.833
Primary and unclassified hospitals	12 (8.8)	7 (10.1)	5 (7.5)	
Secondary hospitals	19 (14.0)	10 (14.5)	9 (13.4)	
Tertiary hospitals	105 (77.2)	52 (75.4)	53 (79.1)	
Hospital category				0.743*
General hospital	127 (93.4)	65 (94.2)	62 (92.5)	
Specialized hospital and others	9 (6.6)	4 (5.8)	5 (7.5)	
Diagnosis on basis of epidemiological history				0.243
Yes	117 (86.0)	57 (82.6)	60 (89.6)	
No	19 (14.0)	12 (17.4)	7 (10.4)	
Answered the definition accurately				0.581
Yes	12 (8.8)	7 (10.1)	5 (7.5)	
No	124 (91.2)	62 (89.9)	62 (92.5)	
Knew the surveillance system for PUE				< 0.001
Yes	110 (80.9)	65 (94.2)	45 (67.2)	
No	26 (19.1)	4 (5.8)	22 (32.8)	
Received in-hospital training related to PUE				< 0.001
Yes	107 (78.7)	64 (92.8)	43 (64.2)	
No	29 (21.3)	5 (7.2)	24 (35.8)	
Participated in in-hospital emergency drills related to PUE				0.001
Yes	94 (69.1)	57 (82.6)	37 (55.2)	
No	42 (30.9)	12 (17.4)	30 (44.8)	
Established a hospital-based expert panel on PUE				< 0.001
Yes	105 (77.4)	64 (92.8)	41 (61.2)	
No or unclear	31 (22.8)	5 (7.2)	26 (38.8)	

P-values comparing different groups were from χ^2 test or Fisher's exact test, *Fisher's exact test.

Table 2. Significant factors influencing clinicians' likelihood to report pneumonia of unknown etiology cases.

Variables	*OR* (95% *CI*)	*P*-value
Received in-hospital training related to PUE		
Yes	4.48 (1.49-13.46)	0.008
No	Reference	
Established a hospital-based expert panel on PUE		
Yes	5.46 (1.85-16.11)	0.002
No or unclear	Reference	

All varialbes with $P<0.10$ in univariate analysis were included in the multivariate logistic analysis. Differences were considered statistically significant at $P<0.05$. This table only presents the significant variables from multiple logistic regression analysis.

cases than those aged ⩽37 years old (17.4% *vs.* 10.3%) ($P=0.001$). Clinicians with >12 years of clinical work diagnosed PUE cases at a higher rate than those with ⩽12 years of clinical work (17.1% *vs.* 10.7%) ($P=0.004$). The PUE case diagnosis rate increased as the clinicians' professional title advanced ($P<0.001$). Clinicians from tertiary hospitals diagnosed PUE cases at a higher rate than those from primary and unclassified hospitals ($P<0.001$). Additionally, significant differences in the clinicians' age, duration of clinical work experience, professional title, and hospital grade were detected between the group who had reported PUE cases and those who had not.

3.2. Identification and report of PUE cases

Among the 989 participants, only 9.1% (90/989) accurately identified the PUE case definition. Most of the clinicians (64.3%, 636/989) inaccurately assumed that all pneumonia cases without a clear pathogenic diagnosis were considered PUE, and 61.4% (607/989) erroneously equated suspected cases of SARS or human avian influenza with PUE cases. Most participants (75.1%, 743/989) were aware of the PUE surveillance system, especially clinicians who worked in the infection department.

Significant differences were detected in the clinicians' awareness of the PUE surveillance system, attendance of in-hospital training related to PUE, participation in the emergency drills related to PUE, and whether their hospital had an expert panel on PUE between the group who had reported PUE cases and those who had not (Table 1).

3.3. Factors influencing the reporting process

Further analysis was performed on the 136 clinicians who had diagnosed PUE cases to explore factors affecting the reporting process.

When clinicians encountered suspected cases of PUE, 88.2% (120/136) would deliver specimens to the Centers for Disease Control and Prevention (CDC) for testing, 5.9% (8/136) collected specimens but did not deliver them to the CDC, and 5.9% (8/136) did not collect specimens. Forty-two clinicians ordered full-scale pathogen testing, which involves bacterial, viral, mycoplasma, chlamydia, parasite, and DNA high-throughput genetic testing of pathogenic microorganisms.

The *Chi*-square test and Fisher's exact test (Table 1) detected five variables with significant differences ($P<0.10$) between participants who had reported PUE cases and those who had not, including the clinicians' specialty, awareness of the PUE surveillance system, receipt of in-hospital training related to PUE, participation in in-hospital emergency drills related to PUE, and whether their hospital had an in-hospital expert panel on PUE, which were further included in the multivariate logistic analysis. The multivariate logistic regression results revealed that clinicians who had attended in-hospital training were more likely to report PUE than those who had not (*OR* 4.48, 95% *CI* 1.49-13.46). Clinicians with an expert panel in their hospital were more likely to report PUE than those without an expert panel in their hospital (*OR* 5.46, 95% *CI* 1.85-16.11) (Table 2).

Additionally, clinicians were asked about the reasons hindering their reporting. Of the 136 clinicians who diagnosed PUE cases, 75.7% (103/136) had difficulty ruling out other diseases when diagnosing PUE, 52.9% (72/136) believed that the test technologies in their hospital laboratories were limited, 45.6% (62/136) were unaware of the need to report PUE cases using the PUE surveillance system, and 41.2% (56/136) were afraid of increased workload after reporting. In addition, 39.0% (53/136) of the respondents did not know whether specimens should be sent to the CDC, and 40.4% (55/136) did not know whether the CDC could perform pathogenic testing. Lack of assistance after reporting and the fact that most patients who meet the case definition do not cause a major public health event were also found to influence PUE case reporting. The *Chi*-square test (Table 3) detected two variables with significant differences ($P<0.05$) between the participants who had reported PUE cases and those who had not: the perception of added burden after reporting and the fear of unnecessary trouble caused by reporting errors.

Table 3. Reasons hindering pneumonia of unknown etiology cases reporting among clinicians in China [*n*(%)].

Variables	Clinicians who diagnosed PUE (*n*=136)	Clinicians who reported PUE		*P*-value
		Yes (*n*=69)	No (*n*=67)	
Not aware of the need to report PUE cases in the surveillance system for PUE				0.381
Yes	62 (45.6)	34 (49.3)	28 (41.8)	
No	74 (54.4)	35 (50.7)	39 (58.2)	
Difficulties in ruling out other diseases to make the diagnosis of PUE				0.766
Yes	103 (75.7)	53 (76.8)	50 (74.6)	
No	33 (24.3)	16 (23.2)	17 (25.4)	
The added burden of post-reporting chores				0.022
Yes	56 (41.2)	35 (50.7)	21 (31.3)	
No	80 (58.8)	34 (49.3)	46 (68.7)	
No requirement to report PUE cases				0.476
Yes	32 (23.5)	18 (26.1)	14 (20.9)	
No	104 (76.5)	51 (73.9)	53 (79.1)	
Not sure whether the specimen should be sent to the CDC				0.754
Yes	53 (39.0)	26 (37.7)	27 (40.3)	
No	83 (61.0)	43 (62.3)	40 (59.7)	
Not sure if CDC could do pathogenic testing				0.973
Yes	55 (40.4)	28 (40.6)	27 (40.3)	
No	81 (59.6)	41 (59.4)	40 (59.7)	
No assistance after the report				0.797
Yes	42 (30.9)	22 (31.9)	20 (29.9)	
No	94 (69.1)	47 (68.1)	47 (70.1)	
Fear of causing unnecessary trouble by reporting errors				0.016
Yes	46 (33.8)	30 (43.5)	16 (23.9)	
No	90 (66.2)	39 (56.5)	51 (76.1)	
Many patients meeting the case definition but not causing a major public health event				0.103
Yes	52 (38.2)	31 (44.9)	21 (31.3)	
No	84 (61.8)	38 (55.1)	46 (68.7)	
Limited laboratory testing capabilities				0.856
Yes	72 (52.9)	36 (52.2)	36 (53.7)	
No	64 (47.1)	33 (47.8)	31 (46.3)	

PUE: pneumonia of unknown etiology cases, *P*-values comparing different groups were from χ^2 test or Fisher's exact test, *Fisher's exact test.

4. Discussion

This study revealed the low PUE reporting rates among clinicians in China. Two factors associated with the reporting of such cases were the attendance of in-hospital training related to PUE and the presence of a hospital-based expert panel on PUE. These results indicated that PUE training for all clinicians and the establishment of expert panels on PUE in all hospitals may improve PUE reporting rates.

The PUE surveillance-based reporting system is a crucial tool for controlling outbreaks of pneumonia caused by unknown pathogens and identifying emerging infectious diseases. Until now, few studies in China have investigated the factors affecting the reporting of PUE cases by clinicians. A master's thesis[10] showed that 34.1% (166/487) of surveyed clinicians had reported PUE cases. Among the clinicians who had diagnosed PUE cases, the reporting rate was 66.4% (166/250). However, only 7.0% (69/989) of the clinicians surveyed in the present study had reported PUE cases. Among the 136 clinicians who had diagnosed PUE cases, the reporting rate was 50.7% (69/136). This difference may be because the thesis was based on a sample of two cities (districts) from each of the four provinces (municipalities) (Beijing, Hubei, Zhejiang and Guizhou), and at least one of the cities (districts) had reported PUE cases, which might have increased the reporting rate. In contrast, the present study was conducted using online convenience sampling without considering whether PUE cases had been reported in the clinician's location, which may have led to the relatively low PUE reporting rate in this study. Moreover, compared with the thesis, this study included clinicians from diverse departments, including general internal medicine, pediatrics, and cardiology; clinicians working in these departments may be less likely to encounter pneumonia patients and therefore be less aware of the need to report PUE cases. In addition,

a previous study[4] showed that PUE reporting might be influenced by avian influenza epidemic status, with a higher probability to report observed in H7N9-affected provinces. Some of the clinicians surveyed in the thesis were from Zhejiang province, which was greatly affected by the H7N9 avian influenza epidemic; this provides another possible reason why the thesis reported a higher PUE reporting rate than our study.

Differences in the PUE diagnosis and reporting rates were detected between the 989 clinicians grouped by demographic factors. Clinicians who were older, had a longer duration of clinical work, and had higher professional titles were more likely to diagnose and report PUE cases. Clinicians who have been working longer have more clinical experience and thus would be more likely to encounter, diagnose, and report PUE cases. Clinicians with higher professional titles can be considered more competent and thus may be more likely to diagnose and report PUE cases. The results also indicate that clinicians from tertiary hospitals diagnosed PUE cases at a higher rate than those from primary and unclassified hospitals, which may be attributable to better laboratory testing capabilities at higher-grade hospitals.

Only 9.1% (90/989) of the respondents accurately identified the PUE case definition, consistent with the results of a previous study[11]. More than half of the clinicians surveyed in the present study erroneously equated suspected cases of SARS or human avian influenza with PUE cases. These findings indicate that it is essential for clinicians to master the definition of PUE cases. Clinicians working in the departments of infection and respiratory medicine had a relatively excellent grasp of the PUE definition. Except for clinicians in the infection department, a high proportion of clinicians from the other departments were unaware of the PUE monitoring system, suggesting that all clinicians should be informed about the existence of the PUE surveillance system. Thus, developing better PUE training and emergency drills for clinicians may improve PUE diagnosis and reporting rates.

To the best of our knowledge, this survey is the first to analyze the factors influencing clinicians' reporting of PUE cases according to the problems that may be encountered from the discovery of a potential PUE case to its reporting. Among the 989 clinicians who participated in this study, 246 had encountered suspected PUE cases, and 136 clinicians had diagnosed PUE cases, but only 69 clinicians had ultimately reported PUE cases. Our analysis revealed two factors significantly associated with the reporting of such cases: the attendance of in-hospital training related to PUE and the presence of a hospital-based expert panel on PUE. Clinicians who had received in-hospital training related to PUE were more likely to report PUE cases than those who had not, and clinicians whose hospitals had expert panels on PUE were more likely to report PUE cases than those whose hospitals did not. This result emphasizes the crucial roles of PUE-related training and expert panels in promoting PUE case reporting.

The 136 clinicians who diagnosed PUE cases were asked about the reasons hindering their reporting; 103 (75.7%) reported having difficulty ruling out other diseases when diagnosing PUE, and 72 (52.9%) believed that the test technologies in their hospital laboratories were limited. A previous study analyzed 30 PUE cases reported in Hunan province from 2004 to 2007[12], and found that difficulty ruling out other diseases when diagnosing PUE was a common problem limiting PUE case monitoring. Moreover, clinicians reported that testing capabilities in their hospital laboratories were relatively low. Although more than a decade has passed, the problem remains unresolved, especially in lower-grade hospitals. Therefore, improvements in testing technologies in hospital laboratories are needed to enhance the diagnoses of PUE cases[13,14]. Of the 69 clinicians who reported PUE cases, 34 clinicians were not aware of the need to report PUE cases using the PUE surveillance system. It is possible that these 34 clinicians only reported identified cases to their supervisors but were not aware that they were also required to report PUE cases in the surveillance system. Thus, training must emphasize the requirement to report PUE cases. In addition, clinicians who had reported PUE cases were more prone to consider increased workload after reporting and fearing unnecessary troubles from reporting errors as reasons that hindered them from reporting PUE cases than those who had not reported PUE cases. This result might be attributable to their past experiences after PUE reporting, which may have required them to fill out various forms, perform additional tests on patients, and report to superiors. Clinicians who reported cases of PUE had experienced these affairs, and they were more aware of these affairs which would hinder them reporting PUE cases. Thus, the reporting process should be appropriately optimized[10] to improve reporting rates. Procedures should be established to help clinicians efficiently deal with reporting and identify possible causes of PUE and to exempt them from responsibility if they wrongly report PUE. Additionally, some respondents did not know whether specimens should be sent to the CDC and whether the CDC would perform pathogenic testing after reporting. These reasons emphasize the need to strengthen training on PUE reporting and optimize reporting procedures.

This study was designed to elucidate the current state of PUE cases reporting among clinicians and explore possible factors affecting the reporting process. The study has some limitations. First, convenience sampling was used in this study, and the clinicians surveyed were mainly from three provinces (Shandong, Guangdong, and Hainan), which might have introduced selection bias. Moreover, many clinicians from general hospitals were included in the study, and the results might not apply to other types of hospitals. Finally, this survey was conducted during the COVID-19 pandemic, when healthcare workers were overburdened, which may have contributed to underreporting of PUE. Despite these limitations, the results

provide useful insights for informing policy related to PUE.

Our findings provide preliminary evidence of the factors that influence clinicians' reporting of PUE cases. The results suggest that training on the PUE surveillance system should be promoted and reinforced among medical staff. In particular, all clinicians should be informed about the existence of the PUE surveillance system and the reporting requirements. In addition, testing technologies in hospital laboratories should to be improved, especially in primary and unclassified hospitals. Further investigation would be helpful for identifying the problems in implementing the surveillance-based reporting system and preventing potential emerging infectious diseases.

Conflict of interest statement

We declare that we have no conflict of interest.

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Authors' contributions

Both H.D. and Y.Z. performed data curation and wrote the original draft. Y.C. conducted investigations. J.T. did the formal analysis. Both S.Z. and Y.D. carried out methodologies and visualisations. D.Z. contributed to the final version of the manuscript. All listed authors contributed significantly to the creation of this manuscript, each having fulfilled criteria as established by the ICMJE and all who meet the four criteria are identified as authors. All authors have read and agreed to the published version of the manuscript.

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