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Construction and effect evaluation of a hierarchical training system for nosocomial infection based on hospitals at all levels

Chang. R*.[1] and Meng. D#.[1]

[1]Hospital Infection Management Office, Shanghai Pulmonary Hospital, Tongji University, Shanghai, China

Abstract

INTRODUCTION: Nosocomial infection is a critical global public health issue. The education of medical personnel can effectively enhance compliance with nosocomial infection protocols and reduce the incidence of such infections. However, the current training provided to third-party staff is inadequate, necessitating an urgent enhancement of their knowledge on nosocomial infection through effective and tailored training programs.
OBJECTIVES: The objective is to establish a hierarchical training system for nosocomial infection, customized to meet the specific requirements of hospitals at all levels, and evaluate its efficacy.
METHODS: A questionnaire survey was conducted among third-party staff members at hospitals of different levels to assess their understanding of nosocomial infection prevention measures. Based on the survey results, a hierarchical training system was developed for nosocomial infection among the participants. After the training, a post-training assessment was carried out to evaluate the participants' comprehension of nosocomial infections.
RESULTS: A total of 561 third-party employees participated in the baseline hospital infection knowledge questionnaire. The baseline findings unveiled disparities in the extent to which third-party staff members across various tiers of medical institutions have mastered their knowledge on nosocomial infections. After undergoing hierarchical training, the deficiencies of hospitals at all levels have been rectified, thereby effectively enhancing the level of knowledge regarding nosocomial infections among third-party personnel. The results of multivariate analysis indicate that individuals with limited work experience should enhance their training in medical waste disposal and acquire a deeper understanding of personal protection measures related to nosocomial infections. Moreover, infrequent annual training sessions may impede the comprehension of nosocomial infection among third-party staff.
CONCLUSION: The knowledge of hospital infection among third-party staff at all levels of medical institutions exhibits varying deficiencies. Implementing a hierarchical training approach is a meaningful strategy that effectively enhances the level of hospital infection knowledge among these staff members.

Keywords: Nosocomial infection, Hierarchical training.

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*The First Author: #Corresponding author: Meng Die, Email: mandymengsh@126.com.

1. Introduction

It has been over 170 years since Ignaz Semmelweis discovered the positive correlation between the incidence of puerperal fever and hand contamination among medical staff in 1847[1]. Nowadays, nosocomial infections have emerged as a significant global public health concern[2]. Educating healthcare professionals can effectively enhance compliance with infection control measures in hospitals, improve efficiency, and reduce infection rates[3, 4]. Enhancing knowledge about nosocomial infections not

only directly reduces their occurrence but also minimizes medical disputes and compensation costs for hospitals. By enhancing hospital staff's understanding of nosocomial infections, it indirectly improves their perception and practice rates to prevent outbreaks. Therefore, hospital administrators should prioritize training on nosocomial infections[5].

The survey revealed that dissemination of knowledge regarding nosocomial infection among clinical staff primarily relied on anecdotal accounts from experienced medical personnel. However, these individuals lacked the necessary awareness and comprehensive understanding of national standard requirements and daily work protocols, thus hindering the advancement of standardized nosocomial infection practices[6, 7]. The training provided to staff members is often outsourced to third-party companies, compromising professionalism and timely problem resolution[8]. Additionally, due to variations in job responsibilities, hospitals at different levels also exhibit disparities in their grasp of hospital infection knowledge, including knowledge-attitude-practice aspects. Therefore, it is imperative to enhance the expertise level of third-party personnel involved in hospital infections through effective and tailored training.

2. Materials and Methods

2.1. Data sources

The research sample comprised two hospitals from each level of care, including primary, secondary, and tertiary institutions. A questionnaire survey was conducted to assess the knowledge level of nosocomial infection among third-party staff members before and after targeted training.

2.2. Study

The study involved third-party staff members from each hospital. Initially, a questionnaire was administered to gather detailed information about the staff, including their medical institution, highest level of education, years of experience in the same role, and number of nosocomial infection training sessions attended in the previous year. A comprehensive knowledge questionnaire on hospital infections was designed, covering topics such as disinfection, medical waste management , occupational exposure treatment, and personal protection.

The questionnaire consisted of 20 questions that assessed the participants' understanding of the essential requirements related to each topic area. It was used to assess and evaluate the baseline understanding regarding nosocomial infections among third-party staff members.

After conducting an analysis and evaluation, a tailored training program was developed for hospitals at different levels based on variations in scores across components of baseline hospital infection knowledge among medical institutions. Hierarchical training sessions were then conducted to address specific areas and questions with discrepancies. Following the completion of the training, participants were asked to complete the questionnaire again, allowing for a comparison of changes in each component as well as the overall score before and after the training.

2.3. Hierarchical training methods

The primary training method employed was a combination of PowerPoint (PPT) presentations and lectures. Based on the findings from the initial research, medical institutions at all levels underwent targeted training to enhance their weaker areas, with on-site Q&A sessions conducted to ensure active participation from third-party staff.

2.4. Data collection

A combination of online and paper questionnaires was utilized for the purpose of data collection. The paper questionnaire specifically targeted third-party staff members who did not have access to smartphones. Trained personnel entered all paper questionnaires twice using epidata software, followed by a logical check upon completion of the data entry process.

2.5. Statistics

The data was analyzed using SPSS 21.0 software. Normally distributed statistics were presented as mean ± standard deviation, while non-normally distributed data were expressed as median and quartile. Count data was assessed using the Pearson chi-square test, and Fisher exact test was employed for count data that did not meet the assumptions of the Pearson chi-square test. Multivariate analysis was conducted using logistic regression analysis, with a significance level set at $P < 0.05$ to indicate statistical significance.

3. Result

3.1. Basic Information

At the final baseline, a total of 561 third-party employees participated, comprising 19 in primary care institutions, 99 in secondary care institutions, and 443 in tertiary care institutions. Among them, 258 (46.0%) had less than three years of professional experience; whereas 535 (95.4%) received hospital infection-related training fewer than twice within the preceding year.

A total of 455 third-party employees participated in the training, including 49 from primary medical institutions, 99 from secondary medical institutions, and 307 from tertiary medical institutions. Among them, 97 individuals (21.3%)

had completed education up to primary school level or below, while 302 (66.4%) had less than three years of work experience in their respective fields. Additionally, it was observed that less than twice in the previous year had hospital infection training been attended by 425 participants (93.4%). Relevant details can be found in **Table 1.**

3.2. Baseline scores

A total of 561 third-party employees participated in the baseline hospital infection knowledge questionnaire. The disinfection score was significantly lower in primary medical institutions (3.26±0.73) compared to secondary medical institutions (4.10±0.89) and tertiary medical institutions (4.07±0.99), demonstrating a statistically significant difference (P=0.001). Furthermore, the score for medical waste disposal in tertiary medical institutions (4.36±0.61) was significantly higher than that in primary and secondary medical institutions (P<0.001). Occupational exposure management scores were significantly lower in primary and tertiary medical institutions when compared to those in secondary medical institutions (4.35 ± 0.80), indicating a statistically significant difference found (P<0.001). Similarly, the score for personal protection was notably lower (P<0.001) in primary and tertiary medical institutions as compared to that of secondary medical institutions (4.24 ± 0.82). Please refer to **Table 2** for further details.

Deficiencies are evident across all sectors of primary medical institutions, which serve as the focal point for hospital infection training. The primary inadequacy among third-party staff members in secondary medical institutions lies in their knowledge pertaining to medical waste treatment. Tertiary medical institutions primarily lack effective occupational exposure management and personal protection measures. In view of the distinct shortcomings observed at different levels of healthcare facilities, corresponding training plans have been devised and implemented.

3.3. Rescores after hierarchical training

After the training, there was a significant improvement observed in the scores of all sections within the training cohort. Specifically, primary medical institutions demonstrated statistically significant increases in the disinfection component (P=0.035), occupational exposure treatment component (P<0.001), and total score (P=0.003). Furthermore, secondary medical institutions showed improvements in the medical waste disposal component (P=0.026), while tertiary medical institutions exhibited significant enhancements among the medical waste disposal component (P<0.001), occupational exposure treatment component (P<0.001), personal protection component (P<0.001) and total score (P<0.001). Relevant details can be found in **Table 3**.

3.4. Factors influencing the scores of each section

According to whether each component's score was below or above the group's average, both individual component scores and the total score were categorized into groups below or above the average. Based on results from single factor analysis and a review of relevant literature, potential influencing factors were identified and subjected to logistic regression analysis.

The findings revealed that hierarchical training had a positive impact on all components and the total score, except for disinfection component. In disinfection component, even after adjusting for confounding variables, first-class medical institutions still had a lower proportion of scores exceeding the average compared to third-class medical institutions. In terms of medical waste disposal, primary and secondary medical institutions also had a lower proportion of scores exceeding the average compared to tertiary medical institutions. Additionally, working in the same position for less than 3 years negatively affected scores in this domain. For occupational exposure domain, receiving nosocomial infection training less than twice in the previous year resulted in lower scores for this component. Lastly, working in the same position for less than 3 years lowered personal protection plate's score. Relevant details can be found in **Table 4.**

4. Discussion

The demographic data of the participants indicated that approximately half of the third-party staff members had a work experience of three years or less, which is consistent with previous research highlighting high turnover rates among third-party staff in hospital settings[9]. A significant majority of these individuals participated in hospital infection training fewer than twice within the past year, suggesting a consistent pattern of limited engagement in such training among most third-party staff members, thus corroborating findings from prior studies[10].

The baseline results revealed that disinfection, medical waste management, occupational exposure handling, and personal protection practices in primary healthcare institutions were all below average levels. This could be attributed to the relatively low patient volume, fewer medical procedures performed, and lower requirements placed on primary healthcare facilities. The score for medical waste disposal in secondary healthcare institutions was lower than that of tertiary healthcare institutions. Furthermore, tertiary healthcare institutions exhibited lower scores in terms of occupational exposure treatment and personal protection compared to their counterparts in secondary healthcare institutions. This discrepancy may stem from the heavy reliance of third-party staff members at tertiary healthcare institutions on clinical personnel such as head nurses for assistance following incidents of occupational exposure or other emergencies; thus lacking sufficient knowledge regarding personal occupational

exposure treatment and protective measures. Variations were observed among different components across all levels of medical facilities, indicating disparities in the level of nosocomial infection knowledge mastery among third-party staff members at various types of medical establishments. Implementing hierarchical training programs for all levels of medical facilities would hold significant importance.

After the training, the deficiencies of hospitals at all levels were identified and subsequently improved, indicating that hierarchical training activities can effectively enhance the knowledge level of third-party staff and yield favorable outcomes, which is consistent with previous research findings[11,12].

The results of multivariate analysis revealed that, in addition to hierarchical training, individuals with less than 3 years of experience in their respective roles exhibited lower scores in medical waste disposal and personal protection. This suggests that individuals who have been engaged in their work for a shorter duration should prioritize enhancing their knowledge on medical waste disposal and personal protection. Similarly, attending hospital infection training fewer than 2 times within the previous year resulted in reduced scores for disinfection and occupational exposure components. This indicates that inadequate annual training sessions can lead to a decline in third-party staff's comprehension of hospital infections.

The present study selected a representative sample of hospitals at all levels in Shanghai, thereby ensuring the inclusiveness and representativeness of the data. Moreover, to enhance the credibility of our findings, we conducted a comparative analysis before and after stratified training. However, it is important to acknowledge certain limitations in this study, such as the relatively small scale of primary medical institutions and the limited involvement of third-party staff members. These limitations should be addressed in future research endeavors.

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Table1. Basic information of participants from third-party st

Medical Institution	Primary care institution	1
	Secondary medical institution	9
	Tertiary care institution	4
Educational background	Primary school or below	1
	Above primary school	4
The duration of employment experience	< 3 years	2
	≥ 3 years	3
Numbers of hospital infection training last year	<2 times	5
	≥2 times	2
Total		5

Table 2.The baseline knowledge scores regarding nosocomial infections in medical institutions at all levels.

	Primary medical institution	Secondary medical institution	Tertiary medical institution	F	P
Disinfection	3.26±0.73	4.10±0.89	4.07±0.99	6.6	0.001
Medical waste treatment	4.05±0.52	4.08±0.37	4.36±0.61	11.6	＜0.001
Occupational exposure treatment	3.00±1.11	4.35±0.80	3.53±0.90	39.6	＜0.001
Personal protection	3.53±0.70	4.24±0.82	3.48±1.01	25.4	＜0.001
Total	13.84±1.64	16.78±1.91	15.44±2.48	25.4	＜0.001

Table 3.The assessment of nosocomial infection knowledge in medical institutions at all levels following the training.

		Baseline Population	Training Population	F	P
Primary medical institution	Disinfection	3.26±0.73	3.80±0.98	4.6	0.035
	Medical waste treatment	4.05±0.52	4.33±0.92	1.5	0.228
	Occupational exposure treatment	3.00±1.11	4.16±1.09	15.5	＜0.001
	Personal protection	3.53±0.70	3.82±1.22	0.9	0.334
	Total	13.84±1.64	16.10±3.05	9.3	0.003
Secondary medical institution	Disinfection	4.10±0.89	4.13±0.97	0.1	0.818
	Medical waste treatment	4.08±0.37	4.31±0.97	5.0	0.026
	Occupational exposure treatment	4.35±0.80	4.34±0.98	0.0	0.937
	Personal protection	4.24±0.82	4.23±1.12	0.0	0.943
	Total	16.78±1.91	17.02±3.10	0.4	0.509
Tertiary medical institution	Disinfection	4.07±0.99	4.15±0.92	1.1	0.298
	Medical waste treatment	4.36±0.61	4.62±0.64	31.2	＜0.001
	Occupational exposure treatment	3.53±0.90	4.07±1.06	56.5	＜0.001
	Personal protection	3.48±1.01	3.96±1.19	35.5	＜0.001
	Total	15.44±2.48	16.80±2.92	46.6	＜0.001

Table 4. Factors influencing the scores of each section

			B	S.E	Wals	P	OR
Total Score	Hierarchical training		1.0	0.1	51.7	＜0.001	2.71(2.06-3.55)
	Medical Institution	Primary medical institution	-0.8	0.3	8.1	0.005	0.46(0.27-0.79)
		Secondary medical institution	0.8	0.2	19.0	＜0.001	2.15(1.52-3.03)
		Tertiary medical institution			30.6		
	The primary school level or below		0.0	0.2	0.0	0.961	0.99(0.72-1.37)
	Less than 3 years of work experience		-0.3	0.1	3.5	0.061	0.77(0.59-1.01)
	Less than 2 times of nosocomial infection training in the previous yea		-0.2	0.3	0.6	0.424	0.79(0.44-1.41)
Disinfection	Hierarchical training		0.2	0.1	2.2	0.135	1.22(0.94-1.59)
	Medical Institution	Primary medical institution	-1.2	0.3	14.3	＜0.001	0.29(0.16-0.55)
		Secondary medical institution	0.0	0.2	0.0	0.825	1.04(0.75-1.43)
		Tertiary medical institution			14.8		
	The primary school level or below		-0.1	0.2	0.5	0.467	0.89(0.65-1.22)
	Less than 3 years of work experience		0.1	0.1	1.0	0.322	1.14(0.88-1.49)
	Less than 2 times of nosocomial infection training in the previous yea		-0.8	0.3	7.2	0.007	0.46(0.26-0.81)
Medical waste treatment	Hierarchical training		1.5	0.1	107.6	＜0.001	4.66(3.48-6.23)
	Medical Institution	Primary medical institution	-0.9	0.3	11.1	0.001	0.40(0.23-0.69)
		Secondary medical institution	-1.1	0.2	35.3	＜0.001	0.34(0.24-0.49)
		Tertiary medical institution			40.8		
	The primary school level or below		-0.1	0.2	0.3	0.587	0.91(0.66-1.27)
	Less than 3 years of work experience		-0.7	0.1	25.0	＜0.001	0.48(0.36-0.64)
	Less than 2 times of nosocomial infection training in the previous yea		0.1	0.3	0.1	0.814	1.07(0.59-1.95)
Occupational exposure treatment	Hierarchical training		1.4	0.2	78.2	＜0.001	4.18(3.04-5.73)
	Medical Institution	Primary medical institution	0.4	0.3	1.7	0.192	1.45(0.83-2.54)
		Secondary medical institution	1.6	0.2	79.2	＜0.001	5.10(3.56-7.30)
		Tertiary medical institution			79.2		
	The primary school level or below		-0.3	0.2	2.4	0.122	0.73(0.50-1.09)
	Less than 3 years of work experience		-0.1	0.2	0.2	0.691	0.94(0.68-1.29)
	Less than 2 times of nosocomial infection training in the previous yea		-1.4	0.3	18.0	＜0.001	0.26(0.14-0.48)
Personal protection	Hierarchical training		1.2	0.2	64.8	＜0.001	3.46(2.56-4.67)
	Medical Institution	Primary medical institution	-0.4	0.3	2.0	0.156	0.64(0.35-1.18)
		Secondary medical institution	1.1	0.2	40.1	＜0.001	2.99(2.13-4.19)
		Tertiary medical institution			45.4		
	The primary school level or below		-0.1	0.2	0.5	0.499	0.88(0.61-1.27)
	Less than 3 years of work experience		-0.4	0.2	6.3	0.012	0.68(0.50-0.92)
	Less than 2 times of nosocomial infection training in the previous yea		-0.5	0.3	2.1	0.147	0.63(0.34-1.17)