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Optimization of the specimen delivery process in the emergency department based on root cause analysis and evaluation of its effectiveness

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Abstract: *To investigate the effect of root cause analysis in reducing the time and error of emergency specimen delivery, in this study, the blood samples of 560 patients in the emergency department of a tertiary hospital from June 1, 2024 to December 31, 2024 were selected by convenience sampling method, and they were divided into control group and observation group according to the time of consultation. The incidence of adverse events and hidden events in the observation group was lower than that in the control group (P<0.001), the time of submission for testing was less than that in the control group (P<0.001), and the patient satisfaction was better than that in the control group (P<0.001). The root cause analysis method can reduce the incidence of errors in the submission of emergency specimens, improve the standard rate of submission, reduce the adverse events in the submission process, and shorten the delivery time.*

Keywords: *Emergency Department; Specimen submission; root cause analysis; adverse events; Process optimization*

In the entire healthcare system, hospital emergency testing is at the forefront of diagnosis and treatment, and has an indispensable role in the diagnosis and rescue of patients with acute and critical illnesses[1]. Generally speaking, clinical staff are concerned about the accuracy of the emergency test report, but also attach great importance to the timeliness of the report issued. Emergency specimen turnaround time (TAT) is a key indicator of whether emergency test reports can be issued in a timely manner[2-3], which can be used to assess whether the testing process is efficient, how effective it is, and how satisfied clinicians and patients are with the report issuance time[4]. If the TAT of a blood specimen is too long, the quality of the specimen may be reduced, and the test results may be affected and become inaccurate, or even delay the patient's treatment. Therefore, optimizing the TAT of blood specimens in emergency medicine is of great significance for improving work efficiency, ensuring the accuracy of test results, and providing timely and effective medical treatment.2024 In October, the Emergency Department of a tertiary hospital in Xi'an City, China, used the root cause analysis method to formulate the specific process of specimen collection and the standard operating procedures, to ensure the collection of standardization and normality, and decided to optimize the process of specimen collection and delivery to the resuscitation room of this department. The decision was made to optimize the process of specimen collection and delivery in the resuscitation room of the department to ensure the accuracy of specimen data and improve efficiency. Root cause analysis (RCA)[5] is a quality management model that retrospectively analyzes the causes of adverse events, identifies defects, and develops improved prevention processes to avoid recurrence. The aim of this study is to reduce the error rate of emergency specimen delivery, improve the standardization rate of delivery, reduce the adverse events, and shorten the delivery time with the help of this method, and the results are reported as follows.

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1. Information and Methods

1.1 General information

Blood specimens from patients in the emergency department resuscitation room of a tertiary care hospital from June 1, 2024 to December 31, 2024 were selected for the study using convenience sampling method. The equation was estimated based on the two-sample mean sample size[6]:

$$n=2[(u_{\alpha}+u_{\beta})/(\delta/(\sigma)]^2+0.25u\frac{2}{\alpha},$$

Setting bilateral α=0.05,uα=1.96; β=0.1,uβ=1.282; δ/σ=0.4, and considering a 20% shedding rate, then n≥160. A total of 560 study subjects were actually included. Inclusion criteria: patients aged ≥18 years; patients who entered the resuscitation room for resuscitation by pre-screening and triage; patients or their family members gave informed consent to voluntarily participate in this study; blood specimens were all collected by emergency specialist nurses, who retained the samples and were required to be sent to the Laboratory Department. Exclusion criteria: patients entering the resuscitation room without any disposition directly transferred to the ward; patients with unclear consciousness, patients who died before or after specimen collection, patients who refused or withdrew, and transferred to the hospital. According to the time of the patients' visit to the hospital, they were divided into 280 cases each in the control group and the observation group. The difference between the general information of the two groups was not statistically significant (P>0.05).

1.2 Methods

Control group: conventional specimen delivery procedures were used.

Observation group: adopting RCA profiling on the basis of the control group. Status quo investigation and root cause analysis: (1) After brainstorming, group members analyze in-depth the causes of long specimen delivery time and adverse events in the emergency department according to specific problems, focusing on 6 aspects: personnel, methods, equipment, materials, environment, and management. (2) Improvement measures: develop an implementation plan for specimen delivery in the Emergency Department.

Improvement Measures: ① In order to deeply analyze and solve the problem, the nursing team of the emergency department formed a root cause analysis (RCA) nursing team. The team members include investigators, nurse leaders, charge nurses, and emergency department nurses, with the nurse leader acting as the researcher and fully in charge of the team's work. In order to improve the overall professional level of the team and ensure the efficient development of RCA profiling, the team members received centralized training on the theoretical knowledge of RCA profiling, as well as in-depth study of the knowledge related to specimen delivery and examination. Lectures, case studies, group discussions and other diversified methods were used to help members understand the relevant knowledge and improve their professional ability. Through systematic training, the team successfully applied RCA profiling to practical work, comprehensively sorted out and optimized the specimen delivery process, further strengthened quality control, and effectively improved the overall level of nursing work in the Emergency Department.

② Organize discussions and investigations to clarify the causes and formulate improvement measures: once a specimen delivery error occurs, the team leader will immediately convene team members to carry out in-depth exchanges. In the process of communication, the accuracy of information is strictly controlled to ensure that the content of the discussion is detailed and reliable. The exchange is in the form of brainstorming, members express their own views, combined with on-site investigation, comprehensively sort out the proximal causes of the incident. On the basis of clear proximal causes, the group used scientific analysis methods to dig deeper into the underlying causes. After finding the root cause, the group developed a series of targeted improvement measures oriented to the problem, striving to solve the problem of specimen delivery errors from the root to improve the quality of work.

③ Use of auxiliary tools to analyze the process of the incident, clear root cause: with the help of fishbone diagram, timeline and other auxiliary tools, according to the time sequence combing the whole process of specimen delivery error. From the dimension of whether the materials used for inspection are compliant, whether the equipment is running normally, and whether there are interfering factors in

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the inspection environment, we analyze the direct causes of the inspection errors. On the basis of completing the analysis of the direct causes, the investigation is carried out layer by layer until the root cause behind the specimen delivery error is locked.

④Follow the principle of identifying the root cause and formulating an improvement plan: According to the principle of root cause analysis, the team members focus on the following questions: whether the specimen delivery error will not occur if a certain possible cause is eliminated; whether the delivery error will recur again due to the same factor when the cause is corrected; whether other similar delivery errors will be triggered after the cause is corrected. The team members fully discussed and analyzed these key issues, and finally identified the root causes and formulated improvement measures accordingly.

⑤ Optimize the specimen application process and strengthen the checking mechanism: In order to reduce specimen delivery errors, the Laboratory Department and the Emergency Department collaborated to change the specimen application form from paper to electronic application, where patient information is entered directly through the computer, avoiding errors that may occur when filling out the form manually. At the same time, the Emergency Department regularly carries out business learning activities to unify and standardize the operating procedures for specimen collection and delivery, and requires nursing staff to strictly follow the standards. After the specimen collection is completed, the nurse in charge will first check the information carefully with the patient or family members to ensure accuracy, and then check with the nurse in charge for the second time on the specimen name, the type of test tube and other key information to ensure the accuracy of the specimen information. After the specimen is put into the specimen bag and sent to the Laboratory Department, the system of "Three Checks and Seven Checks" is strictly implemented to double-check the patient's name and the name of the specimen, and the nurse who sends the specimen to the Laboratory Department will sign after checking and confirming the specimen.

1.3 Evaluation indexes

① Compare the incidence of adverse events of specimens in the emergency department of the two groups, including unqualified specimen quality and specimen omission. ② Compare the biochemical out time of the two groups. ③ Compare the average satisfaction of patients in the two groups.

1.4 Statistical methods

Using SPSS 26.0 software to analyze the data, the delivery time of specimens meets the normal distribution, expressed as mean ± standard deviation ($x \pm s$), and the test is performed for comparison between the groups; the number of cases is used to express the adverse events or hidden events of specimens delivered for examination, and the χ^2 test is performed for comparison between the groups. The difference was considered statistically significant at $P<0.05$.

2. Results

2.1 Comparison of general information about the study population

In this study, 560 blood specimens from 560 patients of the emergency department resuscitation room of a tertiary hospital from June 1, 2024 to December 31, 2024 were selected as the study subjects for pre- and post-improvement comparisons, respectively. In the control group, there were 143 males and 137 females; the average age was (56.73±17.22) years; the average number of blood specimens collected was about 5. The diagnosis was 72 cardiovascular diseases, 66 cerebrovascular diseases, 41 respiratory diseases, 20 various types of traumas, 18 gastrointestinal diseases, 12 tumors, 10 renal diseases, 9 poisonings, and 32 other diseases. Comparison of the general information of the two groups of patients, $P>0.05$, no statistical difference, comparable.

2.2 Comparison of adverse events in emergency department specimens between the two groups

Using RCA profiling improved over a 3-month period, 22 emergency department specimens in the control group had adverse events, and 2 cases of adverse or hidden events occurred in the observation group; the results of the chi-square test showed that the incidence of adverse or hidden events in the

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observation group was significantly lower than that in the control group ($P<0.001$), as shown in Table 1 and Figure 1.

Table 1 Comparison of the occurrence of adverse events in emergency department specimens between the two groups (cases)

sports event	number of examples	Missing specimens	Failure of specimen quality	Other events	(grand) total
control subjects	280	8	10	4	22
Observation Group	280	0	2	0	2
χ^2	17.40				
P-value	0.0003				

Note: Adverse specimen events or occult events include specimen omissions, specimen quality failures, and other.

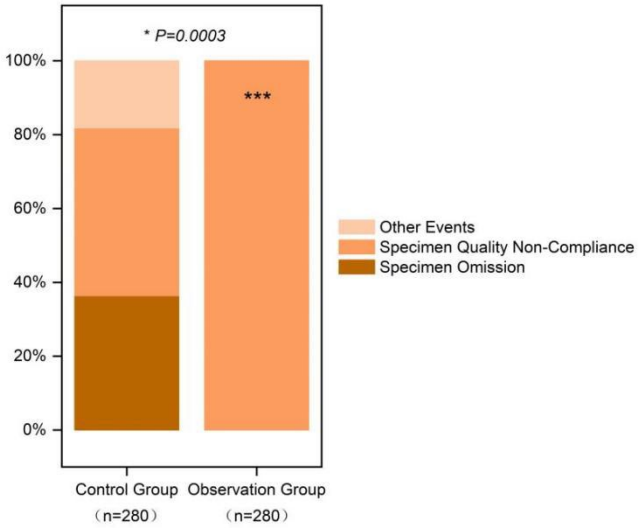

Fig. 1 Comparison of the occurrence of adverse events in the two groups of specimens

2.3 Comparison of specimen delivery time in the emergency department between the two groups

Before and after the improvement using RCA profiling, the specimen exit time of the observation group was significantly shorter than that of the control group ($P < 0.001$), as shown in Table 2.

Table 2 Comparison of specimen exit time (minutes) between the two groups in the emergency department

sports event	number of examples	Inspection time
control subjects	280	38.72±22.41
Observation Group	280	29.70±11.88
t-value	5.06	
P-value	0.000	

2.4 Comparison of average patient satisfaction in the emergency department between the two groups

Before and after improvement using the RCA profiling method, the average patient satisfaction of the observation group was significantly better than that of the control group ($P < 0.001$), as shown in

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Table 3.

Table 3 Comparison of average patient satisfaction (%) between the two groups in the emergency department

sports event	number of examples	Average satisfaction (%)
Observation Group	280	94
control subjects	280	98.3
t-value	-10.17	
P-value	0.000	

3. Discussion

In the emergency department, the accuracy and timeliness of specimen collection and delivery are crucial, which is directly related to the diagnosis and treatment effect of patients, and at the same time, with the development of China's healthcare industry, the construction of emergency testing has become more and more important[7-9]. It has been reported that adverse specimen events may not only lead to diagnostic delays and therapeutic errors, but also increase patients' pain and medical costs, and trigger doctor-patient conflicts[10]. Therefore, it is crucial to optimize and improve the operation process of each link, and to provide standardized training for healthcare personnel to reduce adverse events such as specimen omission and substandard specimen quality.

3.1 RCA-based profiling significantly reduces specimen adverse event rates

In this study, the use of RCA profiling[5] led to a significant reduction in the incidence of adverse events such as missed specimens and substandard specimen quality in emergency medicine, which is consistent with the results of studies such as Mao Suping[11]. Using fishbone diagram and RCA profiling, all proximal causes were argued and analyzed, and the main causes included irregular operation, insufficient training, poor communication, and loopholes in the process by healthcare personnel. In response to operational irregularities, standardized operating procedures were developed and training was strengthened to ensure that each healthcare worker was proficient in specimen collection techniques; in response to insufficient training, targeted training courses were conducted on a regular basis to enhance healthcare workers' awareness of the importance of specimen collection and their operating skills; in response to communication problems, a perfect communication mechanism was established to strengthen the transmission of information between healthcare workers and departments; in response to process loopholes, the optimization of the Specimen management process, reduce unnecessary links, improve work efficiency. The application of RCA profiling in the management of specimens in the emergency department can comprehensively sort out the various aspects of specimen collection, transportation, reception and testing, and explore the potential factors that lead to the occurrence of adverse events. After the implementation of RCA profiling, the incidence of adverse events of specimens in the emergency department was significantly reduced ($P < 0.001$), which not only improved the accuracy and reliability of test results and provided strong support for clinical diagnosis and treatment, but also shortened the time of diagnosis and treatment of patients, and enhanced the satisfaction of patients. At the same time, it also enhances the quality consciousness and teamwork ability of medical and nursing staff, and creates a good medical safety culture.

3.2 RCA-based profiling significantly reduces specimen delivery time and improves patient satisfaction

Prolonged time limits for emergency test reports often cause dissatisfaction among clinicians and patients, and even medical disputes[12-13]. This study focused on the application of the root cause analysis method in shortening the delivery time of emergency medical specimens and achieved significant results ($P < 0.001$). In terms of the implementation process, the systematic and in-depth nature of the root cause analysis method is key. Through the formation of a multidisciplinary team covering emergency medical and nursing personnel, inspectors, etc., the data from all aspects of the specimen delivery process were comprehensively collected, including the specimen collection

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completion time, waiting time for transfer, actual transfer time, and the acceptance time of the Laboratory Department. Using the fishbone diagram, RCA analysis method and other tools, layer by layer analysis, accurate positioning of the root cause of the long delivery time. For example, it was found that the scheduling of transporters was chaotic and there was a lack of a unified coordination mechanism, which resulted in specimens spending a lot of time waiting for transporters; in addition, the lack of standardization of the specimen collection process resulted in unstable collection time, which indirectly lengthened the overall length of the delivery of the test. To address these root causes, targeted improvement measures have been developed and implemented. Detailed and standardized specimen collection procedures were developed, and training for medical and nursing staff was strengthened to ensure standardized and rapid collection operations and reduce the time wasted in the collection process. After the implementation of the improvement measures, the effect is remarkable. The average delivery time of emergency specimens has been significantly shortened compared with the previous period, which has bought valuable time for subsequent tests and diagnosis. This not only improves the timeliness of test results, but also enables doctors to make diagnosis and treatment decisions in a timely manner based on accurate test data, which improves the efficiency of patient treatment and improves patient prognosis.

In healthcare, patient satisfaction is a key indicator of overall quality[14], and RCA profiling opens a new path to improve patient satisfaction. After the implementation of root cause analysis, patient satisfaction was significantly increased ($P < 0.001$), and the hospital's reputation and competitiveness were enhanced. However, there are challenges in the promotion, such as the difficulty in changing the mindset of healthcare workers and resistance to departmental coordination. In the future, training should be strengthened, understanding should be improved, an efficient coordination mechanism should be established, and the root cause analysis method should be fully utilized to continuously improve patient satisfaction.

4. Summary

In order to improve specimen delivery rates, the Emergency Department has established a comprehensive control of nursing safety based on root cause analysis to further refine and enhance the specimen turnaround process to consistently reduce adverse specimen events and shorten specimen delivery time. However, some challenges were encountered during the application of the root cause analysis method. Some staff members were not very receptive to the new method and were initially resistant to it, which affected the accuracy of data collection and analysis. In addition, the continuous implementation of improvement measures requires a large amount of human and material resources for monitoring and evaluation, which increases management costs. In the future, the training and education of staff should be further strengthened to improve the cognition and application ability of the root cause analysis method. At the same time, the monitoring and evaluation mechanism should be optimized, and management costs should be reduced with the help of intelligent management tools, so as to continuously consolidate and expand the achievements of the root cause analysis method in shortening the delivery time of specimens in emergency medicine, and to provide stronger support for the improvement of the quality of emergency medical services.

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