

Effect of Cluster Nursing Based on Root Cause Analysis in Preventing Unplanned Extubation

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Abstract: This study investigates the efficacy of root cause analysis-based bundled nursing in preventing unplanned extubation. **Methods** A systematic analysis of unplanned extubation cases over the past two years was conducted using root cause analysis. Standardized catheter care protocols were developed for key components including patient assessment, catheter fixation, nursing rounds, and health education based on identified risk factors. **Measures** The study employed a controlled trial design, selecting patients admitted between January 1, 2025 and March 1, 2025 as the control group, and those admitted between April 1, 2025 and June 1, 2025 as the observation group. The control group received traditional catheter fixation methods and standard care protocols, while the observation group adopted innovative fixation techniques combined with standardized care. Both groups were compared in terms of effective fixation days and patient satisfaction. **Results** The root cause analysis-based bundled nursing model significantly improved catheter retention duration, with the observation group showing higher average retention days than the control group (statistically significant, $P < 0.05$). Patient satisfaction also demonstrated a statistically significant advantage in the observation group. **Conclusion** Root cause analysis-guided bundled nursing not only reduced catheter dislodgement rates but also enhanced the systematicness and specificity of nursing interventions while establishing standardized quality management protocols. This model provides a scientific solution for clinical catheter care, offering practical value in ensuring patient safety and optimizing resource allocation.

Keywords: Root Cause Analysis; Bundle-Based Nursing; Unplanned Extubation; Quality Improvement in Nursing; Effectiveness Evaluation; Clinical Practice.

1. Background

In clinical practice, unplanned extubation remains a critical safety risk. When catheters accidentally dislodge, they may not only cause immediate complications like bleeding but also prolong treatment duration and increase medical costs [1]. Particularly during postoperative recovery, these essential life-support devices can simultaneously serve as potential safety hazards. While current clinical protocols primarily rely on routine nursing measures for prevention, several limitations persist: inadequate real-time assessment of catheter dislodgement risks, lack of innovative fixation techniques, inconsistent health education approaches, and non-standardized management systems [2], all contributing to persistently high unplanned extubation rates. Traditional response strategies lack systematic preventive mechanisms, making it difficult to fundamentally control this risk.

In recent years, the concept of bundle nursing has demonstrated unique advantages in catheter management. This model integrates multiple evidence-based nursing measures to establish standardized intervention protocols [3], effectively transforming passive care into proactive care that has achieved remarkable results across various disease management scenarios [4]. However, current practices predominantly focus on optimizing operational procedures while lacking systematic analysis of risk triggers, resulting in insufficiently targeted nursing interventions. Root Cause Analysis (RCA), as a quality management tool, can thoroughly examine underlying factors behind incidents, providing evidence for developing precise intervention strategies and ultimately reducing risks [5].

This study aims to develop a root cause analysis-based bundled nursing model. By identifying key triggers for

unplanned extubation, it establishes standardized intervention protocols covering risk assessment, catheter immobilization, health education, and staff training. The research focuses on demonstrating the model's effectiveness in reducing tube dislodgement rates and improving care quality, providing clinicians with scientifically grounded yet practical solutions for clinical practice.

2. Data and Methodology

2.1. General Information

In the preliminary phase of this study, root cause analysis was conducted on six unplanned tube removal adverse events occurring in our department between January 2023 and January 2025. After establishing standardized nursing protocols through bundled care, a controlled trial design was implemented. The control group comprised 73 patients with indwelling tubes admitted from January 1 to March 1, 2025, while the observation group included 72 such patients admitted from April 1 to June 1, 2025. Statistical analysis demonstrated no significant difference in baseline demographics between groups ($P > 0.05$), confirming their comparability. Inclusion criteria: age ≥ 18 years, presence of at least one therapeutic catheter with an estimated retention time exceeding 24 hours, and patients with consciousness levels within cooperative range. Exclusion criteria included severe coagulation disorders, skin damage affecting catheter fixation, and patients with psychiatric or speech impairments.

2.2. Methodology

2.2.1. Root Cause Analysis of Unplanned Extubation Adverse Events

- (1) Establish a Root Cause Analysis (RCA) team

comprising nursing managers, clinical nurses, and quality control specialists. The team consists of a head nurse, two team leaders, and three core nursing staff members. The head nurse oversees overall guidance and supervision. Team leaders coordinate operational tasks, while the team members are responsible for quality assurance.

(2) The RCA team conducted a retrospective analysis of unplanned extubation incidents identified in the past two years. Through interviews with involved parties, they reconstructed event timelines including psychological factors, adverse outcomes, and complications while identifying risk factors and compiling evidence-based data to pinpoint root causes. Utilizing the SeverityAssessmentCodeMatrix (SAC), decision trees were employed to analyze anomalies, and brainstorming sessions were conducted using the "Swiss Cheese Model" framework[6]. This approach examined four dimensions: environmental influences, safety oversight, precursors to unsafe behaviors, and unsafe operational practices. By applying the "Five Whys" method, team members systematically addressed surface-level issues through multi-dimensional analysis, ultimately identifying

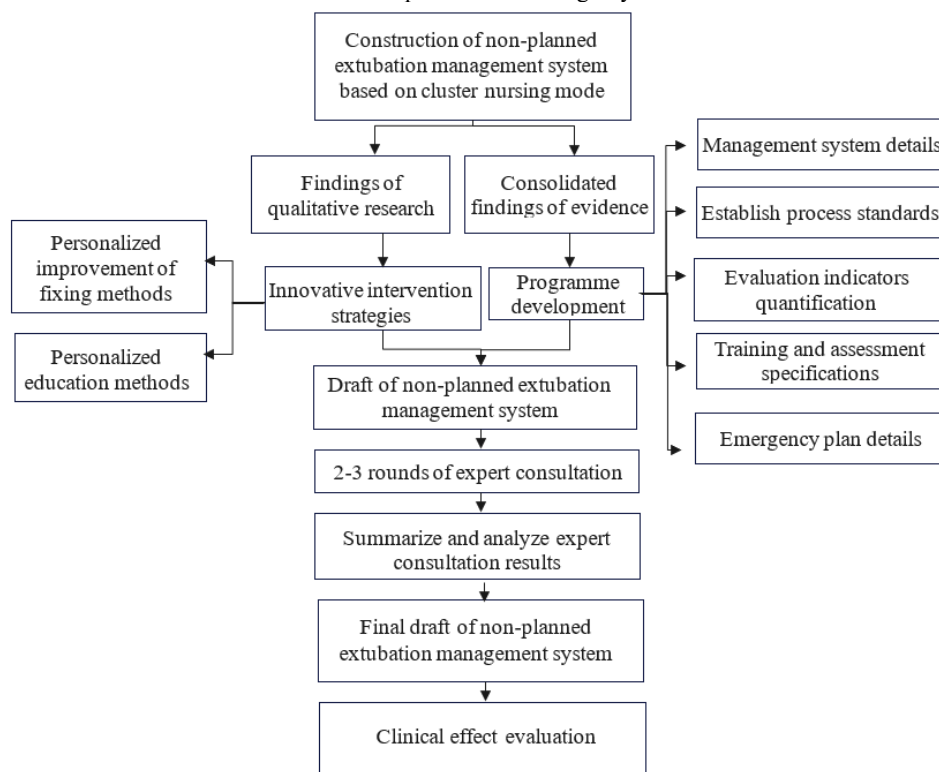
four actionable root causes: 1)inadequate fixation of drainage tubes, 2)absence of standardized extubation prevention education protocols with effective feedback evaluation criteria, 3)deficiencies in drainage tube safety management standards and procedures, 4)and lack of corresponding training and assessment systems. These findings provided actionable guidance for subsequent corrective measures.

2.2.2. Build a Cluster Nursing Plan.

(1) The activity plan shall be drawn up in accordance with the "4W1H" principle, and the Gantt chart shall be drawn to formulate the activity plan. The PDCA management principle shall be followed to formulate the activity details.

(2) Conduct evidence retrieval based on root causes and literature-validated evidence-based questions, followed by quality evaluation and evidence summarization with classification [7]. Summarize the best evidence for nursing management of unplanned extubation, and establish an unplanned extubation management system based on the bundled care model (Table 1).

Table 1. The process of building a system



2.2.3. Application Scheme the Design of Cluster Nursing Measures Follows the Principle of "Precise Correspondence and Systematic Integration"

(1) Apply standardized training and assessment plan to carry out nursing training and assessment for preventing unplanned extubation, including formulating assessment scoring standards, setting up special training plan for pipeline management, and strictly implementing pipeline fixation operation standards.

(2) Fully implement the nursing process and management standards for preventing unplanned extubation, including: handover standards, fixation and identification standards, assessment tools and hierarchical management, nursing

inspection and documentation standards, health education and feedback mechanism, emergency plan, etc.

(3) Novel Catheter Fixation Method: Skin preparation-adhesive tape trimming-multi-point fixation-tension testing, with visualized operational guidelines. For patients requiring prolonged indwelling drainage tubes, implement new dressing changes by instructing patients and their families on secure fastening techniques and key points through visualized guidance. Using a controlled trial design, we selected patients admitted between January 1, 2025 and March 1, 2025 as the control group, and those admitted between April 1, 2025 and June 1, 2025 as the observation group.

Control group: Implement the conventional nursing mode: 1) adopt the traditional pipeline fixation method; 2) do a good

job in pipeline identification; 3) do a good job in pipeline handover.

The observation group used a new pipeline fixation method and cluster nursing measures based on root cause analysis.

(4) In terms of health education and feedback, the same control trial method was used to select patients admitted in the department from January 1, 2025 to March 1, 2025 as the control group, and patients admitted from April 1, 2025 to June 1, 2025 as the observation group.

Control group: Implement conventional health education model

Observation group: Strengthen the pipeline safety education for patients and their families, strictly follow the education process, use the education manual and visual video, and provide feedback on the effect through the "Notice of Unplanned Tube Removal", so as to ensure that patients and their families fully grasp and attach importance to it.

(5) The implementation framework emphasizes a closed-loop management system of "training-execution-feedback". First, specialized training for nursing staff is conducted to master root cause analysis through scenario simulations, with focused training on catheter fixation techniques and risk assessment skills. During clinical execution, bedside shift handover protocols are implemented to ensure each shift completes critical procedures including catheter status checks and fixation device maintenance. The quality control system features daily catheter safety inspections, monthly case discussions, and quarterly data analysis, establishing a continuous improvement mechanism.

2.3. Observation Indicators:

1) Completion rate of nursing staff training and assessment.

2) Effective days of tube fixation, closely monitor the effective fixation days of tubes in both groups of patients and the reasons for loosening, record and analyze them in a table. 3) Effectiveness rate of health education feedback. 4) Nursing satisfaction (using self-designed questionnaire with Likert 5-point scale, each item 1-5 points, total 20 items, 100 points in total; higher scores indicate higher patient satisfaction with nursing services)

2.4. Statistical Methods

SPSS27.0 software was used for statistical analysis. Quantitative data were expressed as ($\bar{x}\pm s$) and tested by t-test; count data were expressed as frequency and percentage (%) and tested by χ^2 test. $P < 0.05$ was considered as statistically significant.

3. Results

The rate of standardized training completed by nursing staff in the department was 100%, and the rate of scenario simulation assessment was 100%. The score of theoretical knowledge mastery ability after training (96.5) was higher than that before training (88.5), and the difference was statistically significant.

Comparison of Effective Fixation Days Between Groups: The observation group showed significantly longer effective fixation days than the control group ($P < 0.05$). Except for the gastric tube requiring daily adhesive tape replacement and unchanged fixed method for deep vein catheterization, all other tubing routes in the observation group maintained statistically significant longer fixation days compared to the control group ($P < 0.05$), as shown in Table 2.

Table 2. Comparison of two groups of fixed days

variate-value	sample capacity	average value	standard deviation	T checkout	Welch'sT test	Mean difference	Cohen'sd value
observation group	62	2.452	0.899	T=-7.56 P=0.000***	T=-8.064 P=0.000***	1.285	1.558
control group	38	3.737	0.685				
amount to	100	2.94	1.033				

Note: ***, *, * represent the significance level of 1%,5% and 10% respectively

Health Education After using the teaching manual and visual video, the effect feedback was made by using the "Notice of Unplanned Tube Removal", and all the observation group confirmed that they had mastered and signed the notice.

Comparison of nursing satisfaction between the two groups the nursing satisfaction score of the observation group was (99.34 ± 4.34), which was higher than that of the control group (88.51 ± 10.45), and the difference was statistically significant ($t=-3.022$, $P=0.003$).

4. Discussion

This study developed a clinically applicable prevention model for unplanned extubation by systematically integrating root cause analysis with bundled nursing principles. Practical evidence demonstrates that this approach significantly enhances catheter care safety through scientific risk identification [8] and standardized protocols. Key findings include: 1) Multi-dimensional root cause analysis enables precise identification of nursing vulnerabilities, allowing

more targeted preventive measures; 2) Bundled nursing standardizes critical procedures like patient positioning and tube fixation, effectively reducing quality variations caused by operator inconsistencies; 3) A closed-loop quality management system ensures consistent implementation of protocols. These improvements collectively achieved a substantial reduction in unplanned extubation rates while enhancing the nursing team's risk assessment and emergency response capabilities.

While demonstrating positive outcomes, this study has several areas for improvement. First, the long-term stability of intervention effects requires further observation due to time constraints, particularly the sustained impact of improved nursing practices that demands extended tracking. Second, the effectiveness of the current protocol in specialized patient populations (e.g., those with severe cognitive impairment) warrants deeper exploration, and personalized care strategies need refinement. Additionally, the integration of information technology remains underdeveloped. Future efforts could focus on creating intelligent early-warning systems to

enhance risk prevention efficiency through real-time monitoring of catheter conditions.

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