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Application of the PDCA Cycle in Improving the Compliance Rate of Patient Handoff Content in the Post-Anesthesia Care Unit

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Abstract

Objective: To improve the compliance rate of patient handoff content in the post-anesthesia care unit (PACU), reduce handoff defects, and safeguard perioperative patient safety. **Methods:** A single-center pre-post quality improvement design was adopted. Within two prespecified one-month study windows (February and August 2025), all eligible consecutive patients admitted to the PACU after general anesthesia were enrolled, comprising 136 patients in the pre-improvement group and 200 in the post-improvement group. Guided by the PDCA cycle, four countermeasures were implemented: flexible staffing with float nurse deployment; a standardized SBAR handoff process with closed-loop personal digital assistant (PDA) management; scenario-based simulation training; and multi-dimensional quality control. Baseline characteristics, handoff content compliance rates, and the distribution of handoff defect items were compared between the two groups. Categorical data were analyzed with the chi-square test or Fisher's exact test, and normally distributed continuous data with the independent-samples t-test. **Results:** The handoff content compliance rate was 80.15% (109/136) before improvement and 96.00% (192/200) after improvement, with a statistically significant difference ($\chi^2 = 21.80$, $P < 0.001$). The target achievement rate was 123.63% and the improvement rate was 19.78%. Defect items per 100 handoffs decreased from 43.38 to 4.00. No significant differences were found between the two groups in sex, age, ASA classification, surgical type, operation duration, or anesthesia method (all $P > 0.05$). **Conclusion:** The observed increase in handoff content compliance and the reduction in handoff defects were temporally associated with implementation of the PDCA-based bundled intervention; the uncontrolled pre-post design cannot establish a causal effect. The bundled approach may nevertheless provide a reference for handoff quality improvement in PACUs of comparable hospitals. The long-term effects and the impact on patient clinical outcomes

still require follow-up verification.

Keywords

Post-Anesthesia Care Unit, Shift Handoff, PDCA Cycle, Handoff Standardization, Patient Safety, Quality Management

1. Introduction

The post-anesthesia care unit (PACU) is the critical setting in which surgical patients transition from an anesthetized state to wakefulness. While in the PACU, patients exhibit marked fluctuations in vital signs and a high risk of complications, and the quality of nursing care directly affects patient prognosis and safety [1]. The handoffs that occur when patients are transferred from the operating room (OR) into the PACU and from the PACU out to the ward or intensive care unit (ICU) are core nodes of perioperative care continuity; omitted information or non-standardized handoff can directly lead to adverse events such as medication errors and delayed treatment [2] [3]. A cross-sectional survey by Zemedkun *et al.* [2] showed that non-standardized PACU handoff practices were positively associated with the risk of adverse events. A review by Wang *et al.* [3] noted that PACU handoff models vary and lack a unified standard, and that the use of structured communication tools can reduce information transfer defects. In a multicenter study conducted across nine hospitals, Starmer *et al.* [4] found that after implementing a handoff program centered on a structured communication tool (I-PASS), medical errors and preventable adverse events decreased by approximately 23% and 30%, respectively, providing relatively high-level evidence for structured handoff. Wang *et al.* [5] developed an SBAR-based bedside nursing handoff checklist for the ICU and likewise demonstrated that standardized verification improved handoff completeness. In China, Jiang *et al.* [6] constructed an ISBAR anesthesia handoff framework and validated it in the PACU, achieving a marked improvement in handoff completeness. Xiang *et al.* [7] optimized the handoff checklist for patients transferred from the OR to the PACU after general anesthesia and proposed that verification content should cover key dimensions such as completion of the transfer record, clinical condition handoff, and inventory of patient belongings. With respect to training, scenario-based simulation has been shown to effectively improve nurses' handoff competence and clinical decision-making under high-pressure situations [8] [9]. As a management tool, the PDCA (Plan-Do-Check-Act) cycle—through continuous problem identification, root cause analysis, implementation of countermeasures, and standardization—has been widely applied in nursing quality improvement. Duan *et al.* [10] reported that the PDCA cycle reduced the defect rate of PACU admission handoffs from 7.05% to 1.39%; Xiao *et al.* [11] and Zhang *et al.* [12] also reported that PDCA-based management improved PACU handoff quality.

However, existing studies have mostly focused on the effects of one or two countermeasures. Reports on the systematic integration of flexible staffing, information-technology-based closed-loop management, scenario-based training, and multi-dimensional quality control—as well as psychometric details of the measurement process such as inter-rater reliability—remain insufficient. Taking the PACU of our hospital as the setting, we conducted a PDCA-based quality improvement project from February to September 2025, aiming to improve the compliance rate of PACU patient handoff content through a multi-dimensional bundled intervention. The findings are reported below.

2. Materials and Methods

2.1. Study Participants

During two prespecified one-month study windows (February and August 2025), all eligible consecutive patients transferred to the PACU after general anesthesia were prospectively observed and enrolled, comprising 136 patients in the pre-improvement group and 200 in the post-improvement group. The two calendar months were selected for pragmatic (convenience) reasons of project timing; within each window, however, every eligible admission was approached consecutively rather than chosen from among eligible patients. Inclusion criteria were: 1) transfer to the PACU after general anesthesia; 2) age ≥ 18 years; and 3) American Society of Anesthesiologists (ASA) physical status class I-III. Exclusion criteria were: 1) emergency resuscitation patients for whom the routine handoff process could not be completed; and 2) patients who developed severe intraoperative complications and required direct transfer to the ICU. According to the PACU admission registers, [X] admissions met the exclusion criteria (pre: [X]; post: [X]), and [no eligible handoff/X eligible handoffs] could not be observed because of [reason, e.g., lack of auditor coverage]; these cases were not included in the denominators. The unit of observation was the handoff of a patient from the OR into the PACU, and each patient contributed only one admission-handoff record.

Ethics statement. This nursing quality improvement project was submitted to the Ethics Committee of Jingzhou First People's Hospital and received [institutional approval/a formal exemption determination] (Approval/Exemption No. [XX], dated [YYYY-MM-DD]). Because the project involved non-interventional observation of routine handoffs and review of existing medical records without altering patient care, the Committee granted a waiver of written informed consent for patient observation; all patient data were de-identified and contained no information that could identify individual patients. The video recordings used for simulation debriefing and surveillance-based quality control involved nursing staff rather than patients. Staff appearing in the recordings were informed in advance of their purpose, retention period, and access controls and provided [written/verbal] consent; all recordings were stored on password-protected institutional devices and deleted after project completion.

2.2. Study Methods

The PDCA cycle management method was adopted, and quality improvement was implemented in four phases from February to September 2025; the implementation schedule is shown in Figure 1. Each phase is reported in accordance with the SQUIRE 2.0 (Standards for Quality Improvement Reporting Excellence) reporting guidelines [13].

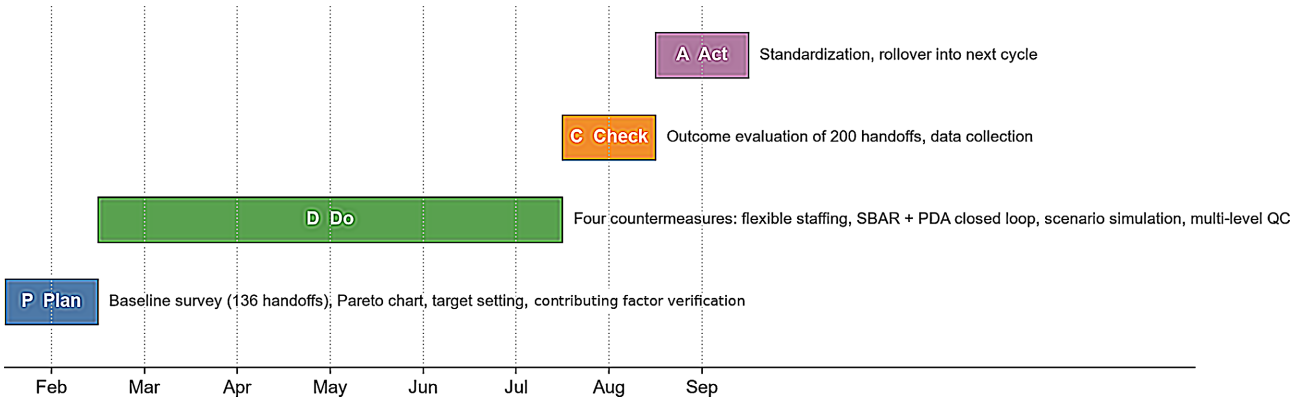


Figure 1. Schedule of the PDCA quality improvement project (February-September 2025).

2.2.1. Plan Phase

1) Baseline survey. In February 2025, the head nurse and the quality control charge nurse conducted continuous observation of 136 consecutive PACU admission handoffs, combining direct observation with medical record review. Before the survey, the department developed a PACU handoff Standard Quality Audit Checklist and trained two auditors. To assess inter-rater reliability, both auditors independently rated the same set of [XX] handoffs (approximately [XX]% of the observed sample) without discussing their ratings beforehand; the agreement between their independent results was measured by the Kappa coefficient and indicated substantial agreement (Kappa = 0.82). Any disagreement was resolved by joint re-examination of the observation notes and the source medical documents; if consensus could not be reached, the head nurse served as a third reviewer and made the final adjudication, and the resolved rating was used in the analysis. A handoff was defined as compliant only when all seven dimensions were passed; failure of any single dimension rendered the handoff non-compliant, and more than one defect could occur in a single handoff. The operational pass/fail criteria for the seven dimensions are listed immediately below. The baseline compliance rate was 80.15% (109/136), with 59 non-compliant items distributed across 27 non-compliant handoffs.

Operational pass/fail criteria for the seven dimensions: a) Complete transfer record—pass when every mandatory field of the transfer record was completed with no blank or erroneous entry; fail if any mandatory field was missing, blank, or incorrectly entered. b) Complete handoff content—pass when every item required by the SBAR handoff checklist was communicated; fail if any required item was omitted. c) Accurate clinical condition handoff—pass when the communi-

cated information (level of consciousness, vital signs, airway and oxygenation, intravenous access, drainage tubes, and intraoperative events) was consistent with the medical record and the patient's actual condition; fail if any discrepancy was identified. d) Complete inventory of patient belongings—pass when all belongings (clothing, valuables, dentures, and personal devices) were itemized, physically handed over, and jointly confirmed; fail if any item was missing or undocumented. e) Clear communication of critical issues—pass when key risks and pending tasks (allergies, difficult airway, special medications, blood products, and outstanding procedures) were explicitly stated; fail if any critical issue was not communicated. f) Complete medical documents—pass when all required records (medical record, consent forms, anesthesia and intraoperative records, and specimen labels) were complete and transferred; fail if any document was missing or incomplete. g) Timely archiving of the handoff form—pass when the completed form was archived within the prescribed period ([XX] hours or by the end of the shift); fail if it was archived late or not archived.

2) Pareto analysis. The 59 non-compliant items were categorized and counted. The four leading defects were incomplete transfer record (13 items, 22.03%), incomplete handoff content (12 items, 20.34%), inaccurate clinical condition handoff (11 items, 18.64%), and missing patient belongings (10 items, 16.95%), which together accounted for 77.97% of defects. Based on the Pareto principle (the 80/20 rule), these four items were designated as the improvement priorities (**Figure 2**).

3) Target setting. Taking the standard value of 100% as the upper limit, the target was set according to the formula:

$$\text{Target} = \text{Baseline} + (\text{Standard} - \text{Baseline}) \times \text{Improvement priority} \times \text{Improvement capacity}$$

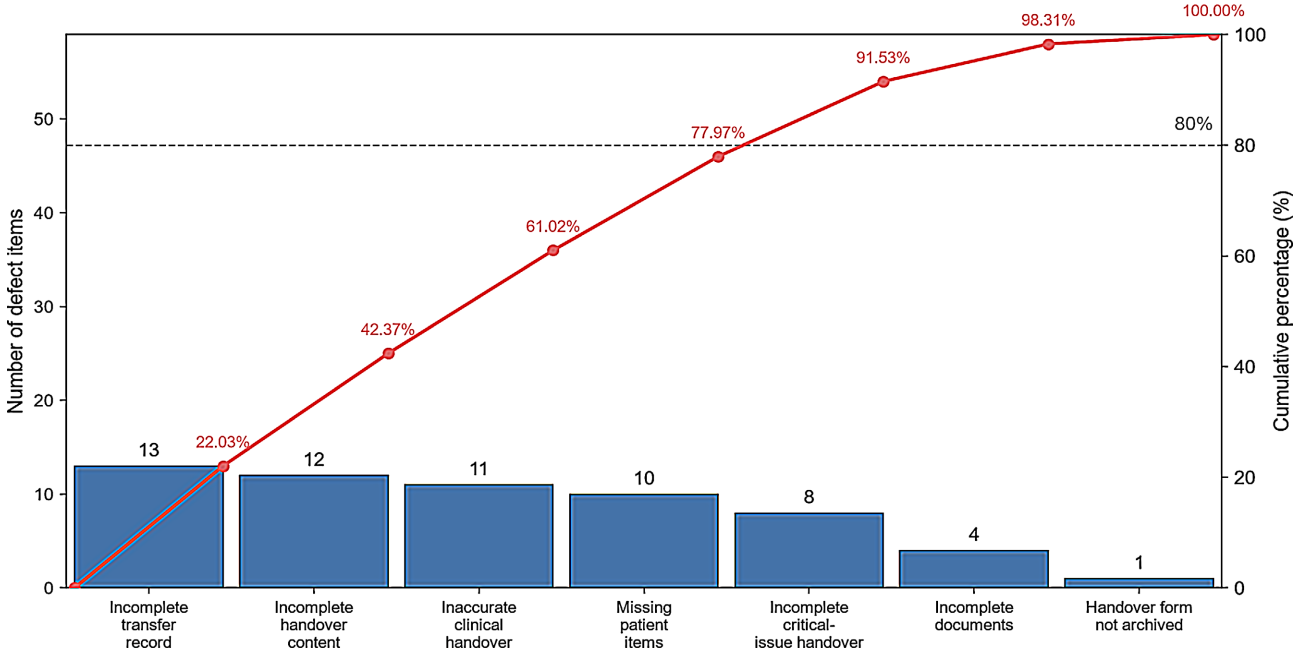


Figure 2. Pareto chart of PACU handoff defects before improvement (n = 59).

The improvement priority was 77.97%, and the improvement capacity, rated by the circle members using a scoring method, was 82.86% (29 of a maximum 35 points). Substitution into the formula yielded:

$$\text{Target} = 80.15\% + (100\% - 80.15\%) \times 77.97\% \times 82.86\% = 92.97\%$$

4) Verification of contributing factors. Brainstorming combined with a fishbone diagram was used to analyze candidate causes from five dimensions—people, equipment, methods, systems, and environment—and eight candidate contributing factors were identified (Figure 3). For each candidate factor, the team prespecified one or more observable defect indicators that could be checked during a handoff (for example, understaffing was indicated by a nurse concurrently handling two or more handoffs, and non-standardized procedures by omission of a mandatory SBAR element). A dedicated verification audit of 30 handoffs was then conducted: for each handoff, the two auditors independently recorded whether each of the eight indicators was present, and the proportion of handoffs in which the indicator occurred (the defect rate) was calculated for every factor. The 80% cutoff was set in advance by consensus at a circle meeting. Consistent with the Pareto (80/20) principle used throughout this project, it served as an operational rule for separating the "vital few" factors from the less frequent ones, rather than as a test of causation. Four factors met or exceeded the 80% threshold and were therefore designated as prioritized contributing factors: insufficient assigned nurses (83.33%), non-standardized handoff procedures (86.67%), inappropriate quality control methods (80.00%), and inadequate training methods (80.00%). This procedure establishes the frequency and priority of these factors within the audited sample; it does not by itself demonstrate that they caused the observed non-compliance.

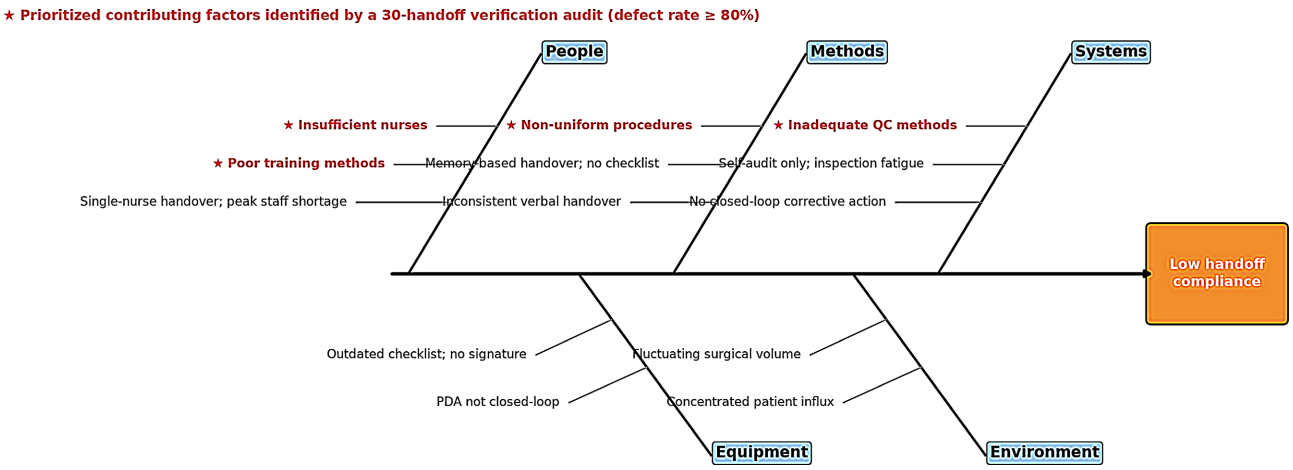


Figure 3. Fishbone (Ishikawa) diagram of low PACU handoff compliance.

2.2.2. Do Phase

Four countermeasures targeting the four prioritized contributing factors were developed and implemented.

Countermeasure 1: Flexible staffing and float nurse deployment. In coordination with the Nursing Department, a cross-departmental nurse support mech-

anism was established (linking the ICU, the neuro-ICU, and the OR). The head nurse dynamically adjusted shifts daily according to the surgical schedule and created mobile assigned-nurse positions to ensure adequate staffing at every post during peak hours.

Countermeasure 2: Reengineering of standardized handoff processes. 1) Closed-loop PDA (personal digital assistant, a mobile handheld terminal) handoff was implemented, the handoff checklist was updated, and both parties verified each item and provided electronic signatures. 2) A standardized SBAR (Situation, Background, Assessment, Recommendation) handoff flowchart was developed and incorporated into routine practice. 3) Single-nurse handoff was replaced by two-nurse handoff, with an anesthesiologist assisting during periods of concentrated patient influx. 4) A departmental handoff feedback group was established for real-time communication. 5) Charge nurses audited 10 handoffs per day and provided immediate feedback on problems.

Countermeasure 3: Scenario-based simulation training. A three-person training group was formed to design multiple handoff scenarios (including sudden clinical deterioration and equipment failure). Nurses engaged in role play, acting as anesthesiologists, OR nurses, PACU nurses, and ward nurses, followed by debriefing through video playback. An unannounced ("surprise") simulation assessment was conducted without advance notice of the scenario, and nurses who failed received intensive training. Knowledge points were pushed through a DingTalk group every Monday, Wednesday, and Friday.

Countermeasure 4: Multi-dimensional quality control. 1) A handoff standard quality audit checklist was developed and applied daily by charge nurses. 2) The head nurse reviewed performance through surveillance video playback. 3) Cross-inspections were conducted jointly with the Nursing Department's three-level perioperative quality inspection team. 4) The results of the three-level inspection were shared to ensure closed-loop corrective action.

2.2.3. Check Phase

In August 2025, an outcome evaluation of 200 post-improvement admission handoffs was conducted using the same evaluation criteria and audit methods as at baseline. The handoff content compliance rate, the distribution of handoff defect items, and changes in circle member competency were compared between the two groups.

2.2.4. Act Phase

The effective countermeasures were incorporated into the department's standardized management procedures, including standardized admission and transfer processes, the SBAR handoff model, and unified inspection standards, forming an institutional standard operating procedure (SOP) system that could be sustained, consistent with the integrated PACU nursing SOP framework reported by Wang *et al.* [14]. Aspects that did not achieve the expected results were carried into the next PDCA cycle.

2.3. Outcome Measures

1) Primary outcome: PACU handoff content compliance rate = (number of compliant handoffs/total number of handoffs) × 100%. 2) Defect-related outcomes: distribution of handoff defect items, number of defect items per 100 handoffs, target achievement rate, and improvement rate. 3) Circle member competency: self-rated scores on eight competencies before and after the project. 4) Patient baseline characteristics: sex, age, ASA classification, surgical type, operation duration, and anesthesia method.

2.4. Statistical Analysis

SPSS 26.0 was used for statistical analysis. Categorical data are expressed as frequencies and percentages and were compared between groups using the chi-square test; when the expected frequency of a 2 × 2 table was below 5 or a zero cell occurred, the two-sided Fisher's exact test was used. Normally distributed continuous data are expressed as mean ± standard deviation ($\bar{x} \pm s$) and were compared using the independent-samples t-test. A two-sided $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of Baseline Characteristics

The pre-improvement group comprised 136 patients and the post-improvement group 200 patients. No significant differences were found between the two groups in sex, age, ASA classification, surgical type, operation duration, or anesthesia method (all $P > 0.05$), indicating comparability (Table 1).

3.2. Comparison of Handoff Content Compliance Rates

Of the 136 handoffs before improvement, 109 were compliant, giving a compliance rate of 80.15%; of the 200 handoffs after improvement, 192 were compliant, giving a rate of 96.00%. The chi-square test showed a statistically significant difference between the two groups ($\chi^2 = 21.80$, $P < 0.001$; two-sided Fisher's exact $P < 0.001$) (Table 2).

$$\text{Target achievement rate} = |\text{post} - \text{pre}|/|\text{target} - \text{pre}| \times 100\%$$
$$= |96.00\% - 80.15\%|/|92.97\% - 80.15\%| \times 100\% = 123.63\%$$

A value exceeding 100% indicates that the target was over-fulfilled. The improvement rate was:

$$\text{Improvement rate} = |\text{post} - \text{pre}|/\text{pre} \times 100\% = 15.85/80.15 \times 100\% = 19.78\%$$

3.3. Comparison of Handoff Defect Items before and after Improvement

Before improvement there were 59 non-compliant items, equivalent to 43.38 defect items per 100 handoffs; after improvement the number fell to 8, equivalent to 4.00 per 100 handoffs. When the occurrence rates of individual defect items

Table 1. Comparison of baseline characteristics between the pre- and post-improvement groups.

Variable	Pre-improvement (n = 136)	Post-improvement (n = 200)	Statistic	P
Sex (male/female), n	68/68	102/98	$\chi^2 = 0.03$	0.86
Age (years, mean ± SD)	52.3 ± 14.6	51.8 ± 15.2	t = 0.30	0.76
ASA classification [n (%)]			$\chi^2 = 0.32$	0.85
Class I	35 (25.74)	48 (24.00)		
Class II	76 (55.88)	118 (59.00)		
Class III	25 (18.38)	34 (17.00)		
Surgical type [n (%)]			$\chi^2 = 0.36$	0.99
General	42 (30.88)	65 (32.50)		
Orthopedic	38 (27.94)	52 (26.00)		
Gynecological	26 (19.12)	41 (20.50)		
Urological	18 (13.24)	24 (12.00)		
Other	12 (8.82)	18 (9.00)		
Operation duration (min, mean ± SD)	125.6 ± 38.2	128.4 ± 41.5	t = 0.64	0.52
Anesthesia method [n (%)]			$\chi^2 = 0.19$	0.66
Combined intravenous-inhalational	88 (64.71)	134 (67.00)		
Total intravenous anesthesia	48 (35.29)	66 (33.00)		

Table 2. Comparison of handoff content compliance rates before and after improvement.

Group	n	Compliant	Non-compliant	Compliance rate (%)
Pre-improvement	136	109	27	80.15
Post-improvement	200	192	8	96.00

Note: Comparison of compliance rates between the two groups: $\chi^2 = 21.80$, $P < 0.001$; two-sided Fisher's exact $P < 0.001$.

were compared by handoff episode, significant improvements were observed for five items—incomplete transfer record, incomplete handoff content, inaccurate clinical condition handoff, missing patient belongings, and incomplete critical-issue handoff ($P < 0.01$); no significant differences were found for incomplete medical documents or handoff form not archived (Table 3).

3.4. Changes in Circle Member Competency

A circle member self-rating scale (7 raters; maximum 5 points per item) was used to evaluate improvement on eight competencies before and after the project. The total score across the eight items increased from 120 (mean 2.14 points per item) to 235 (mean 4.20 points per item). The greatest increases were seen in communication and coordination (2.00 to 4.57), QCC techniques (1.00 to 4.00), and team cohesion (2.29 to 4.57). Details are shown in Table 4 and Figure 4.

Table 3. Comparison of handoff defect items and their occurrence rates before and after improvement.

Defect item	Pre-improvement [n (%)] (n = 136)	Post-improvement [n (%)] (n = 200)	Fisher P
Incomplete transfer record	13 (9.56)	3 (1.50)	0.001
Incomplete handoff content	12 (8.82)	2 (1.00)	0.001
Inaccurate clinical condition handoff	11 (8.09)	1 (0.50)	<0.001
Missing patient belongings	10 (7.35)	0 (0)	<0.001
Incomplete critical-issue handoff	8 (5.88)	1 (0.50)	0.004
Incomplete medical documents	4 (2.94)	1 (0.50)	0.162
Handoff form not archived	1 (0.74)	0 (0)	0.405
Total non-compliant handoffs	27 (19.85)	8 (4.00)	<0.001

Note: More than one defect could occur in a single handoff; therefore the sum of the individual item counts exceeds the total number of non-compliant handoffs. Because the 2 × 2 tables contained expected frequencies below 5 or zero cells, P values are two-sided Fisher's exact probabilities. A total of 59 defect items were recorded before improvement (43.38 per 100 handoffs) and 8 after improvement (4.00 per 100 handoffs).

Table 4. Comparison of QCC member competency scores before and after the project (n = 7; maximum score 5 per item).

Item	Pre total score	Pre mean	Post total score	Post mean	Change
Problem-solving ability	16	2.29	26	3.71	+1.42
Responsibility	21	3.00	28	4.00	+1.00
Communication and coordination	14	2.00	32	4.57	+2.57
Confidence	14	2.00	29	4.14	+2.14
QCC techniques	7	1.00	28	4.00	+3.00
Team cohesion	16	2.29	32	4.57	+2.28
Motivation	16	2.29	30	4.29	+2.00
Harmony	16	2.29	30	4.29	+2.00
Total	120	2.14	235	4.20	—

4. Discussion

4.1. Flexible Staffing and Float Nurse Deployment Underpin Handoff Quality

In the factor verification, "insufficient assigned nurses" was the highest-priority contributing factor, with a defect rate of 83.33%. PACU handoff quality depends heavily on the staffing of nurses on duty; when surgical volume fluctuates markedly, a single nurse may simultaneously undertake handoff and monitoring for several patients, which can easily compromise the accuracy and completeness of information transfer. By establishing a cross-departmental nurse support mechanism and mobile positions, staffing shortfalls during peak hours were alleviated, which may have provided a foundational guarantee for the improvement. This

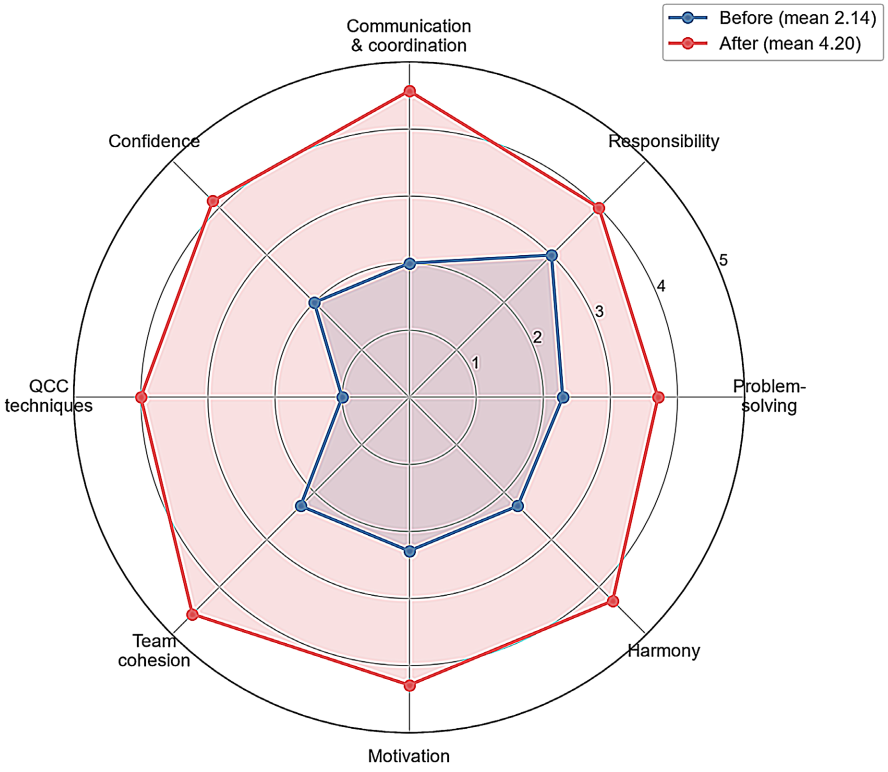


Figure 4. Radar chart of eight competency scores before and after QCC activities (n = 7).

approach is consistent with the PDCA-based PACU nurse shift handoff management proposed by Xiao *et al.* [11], while our study further refined staff deployment through daily dynamic assessment of surgical volume, making scheduling more targeted. It should be noted that the continued operation of the float nurse system depends on the Nursing Department's cross-departmental coordination mechanism; it may be difficult to implement in hospitals with tight staffing and should be advanced step by step according to local conditions.

4.2. Standardized Handoff Processes Combined with SBAR May Reduce Information Omission

The baseline Pareto analysis showed that incomplete transfer records and incomplete handoff content together accounted for 42.37% of defects and were the two leading causes. After improvement, these two defects decreased from 13 to 3 cases and from 12 to 2 cases, respectively. These improvements may be associated with the introduction of closed-loop PDA handoff and the SBAR structured communication model. Item-by-item PDA verification with dual electronic signatures transformed handoff from a memory-based exercise into a checklist-based verification, potentially reducing subjective omission; the SBAR framework unified the organization of handoff content and helped avoid inconsistent handoff emphasis caused by individual habits.

Jiang *et al.* [6] found that an ISBAR framework in a Chinese PACU improved handoff completeness; Kaltoft *et al.* [15] reported similar effects when applying

the ISBAR tool in a Danish postoperative recovery unit; and Wang *et al.* [5] likewise demonstrated the value of standardized checklists with an SBAR-based bedside handoff checklist in an ICU. Duan *et al.* [10] reported a reduction in PACU admission handoff defects from 7.05% to 1.39% after applying the PDCA cycle, consistent with the downward trend in defect density observed here, which suggests that standardized processes are to some extent reproducible across hospital settings. The multicenter study by Starmer *et al.* [4] provides higher-level evidence that structured handoff reduces medical errors. Of note, one case of inaccurate clinical condition handoff remained after improvement, indicating that even with standardized processes, some junior nurses still have room to improve their ability to judge and articulate complex clinical conditions, which should be emphasized in future training.

4.3. Scenario-Based Simulation Training Compensates for the Shortcomings of Traditional Didactic Training

In the factor verification, inadequate training methods had a defect rate of 80.00%. PACU handoff scenarios are complex and variable, including sudden deterioration during transport, equipment failure, and asynchronous information across departments—situations that traditional classroom lectures can hardly cover. In this study, role-play simulation combined with video playback debriefing allowed nurses to experience real handoff pressure in a safe environment, and the training effect may be superior to knowledge-point delivery alone. Guo *et al.* [9] applied scenario-based simulation of cardiac arrest combined with a four-step debriefing method in standardized training for anesthesia department nurses and likewise obtained results superior to traditional teaching; the in situ simulation emergency training course for nursing during anesthesia emergence developed by Dai *et al.* [8] also provides a reference for similar training. A distinctive feature of our study was the addition of unannounced ("surprise") simulations, for which the scenario was not disclosed in advance, testing nurses' real clinical reasoning and emergency response and potentially reducing a "performance" tendency. Nevertheless, the fidelity of some simulation scenarios to actual work still needs improvement, and anesthesia specialists could be invited to revise the scripts in the future.

4.4. Multi-Dimensional Quality Control May Facilitate the Implementation of Countermeasures

Inappropriate quality control methods was one of the prioritized contributing factors (defect rate 80.00%). Intra-departmental self-audit alone is subject to subjectivity and fatigue and is difficult to sustain as a problem-finding mechanism. This study established a three-level quality control system comprising daily charge-nurse audits, head nurse surveillance video review, and cross-inspection by the Nursing Department, with shared findings and closed-loop corrective action. After improvement, the number of handoff defect items fell from 59 to 8, missing patient belongings fell to zero, and incomplete critical-issue handoff fell from 8 to

1, suggesting that multi-dimensional quality control may have promoted the implementation of improvement measures. Funk *et al.* [16] showed that in a pediatric PACU, a structured handoff checklist implemented with direct observation and feedback increased the communication of handoff content and improved provider satisfaction without significantly prolonging handoff time, supporting the value of standardized audit and feedback in sustaining handoff quality. Because all countermeasures were implemented concurrently, the reduction in defects cannot be attributed solely to the quality control measures, and their contribution requires further investigation.

4.5. Limitations

This study has several limitations. First, it used a single-center pre-post design without a parallel control group, and the monthly surgical volumes differed substantially between the February baseline and August post-improvement groups (136 vs. 200 cases); confounding factors such as season, surgical case mix, nurse rotation, and other concurrent management measures could not be completely excluded. Second, the auditors were departmental quality control personnel who could not be blinded to group assignment, and the Hawthorne effect and assessor bias may have influenced the compliance rates. Third, because the four countermeasures were implemented concurrently, the independent contribution of each could not be distinguished, and intervention fidelity was not systematically assessed. Fourth, post-improvement data were collected for only one month; the long-term stability of the improvement and its sustainability after standardization require follow-up verification, and control charts are recommended for continued monitoring. Fifth, the competency assessment was a self-rating by only seven circle members, with a small sample and high subjectivity, and the reliability and validity of the scale were not reported. Sixth, patient clinical outcomes such as adverse events were not included, so the association between improved handoff compliance and patient safety outcomes cannot yet be established.

5. Conclusion

Implementation of the PDCA cycle together with the four bundled countermeasures—flexible staffing; a standardized SBAR handoff process with closed-loop PDA management; scenario-based simulation training; and multi-dimensional quality control—was associated with an increase in the handoff content compliance rate in our hospital's PACU from 80.15% to 96.00% within one month and a reduction in defect items from 43.38 to 4.00 per 100 handoffs, over-fulfilling the preset target. Because this was an uncontrolled pre-post evaluation, these changes cannot be established as causal effects of the intervention. The four countermeasures were mutually supportive and proved feasible within our departmental setting; however, their implementation burden and intervention fidelity were not systematically assessed, so the proposition that they are "readily operable" in other settings should be interpreted with caution. They may nevertheless serve as a ref-

erence for PACU handoff quality improvement in comparable hospitals. Their long-term effects, the independent contribution of each countermeasure, and their impact on patient clinical outcomes require further verification through multicenter controlled follow-up studies.

Author Contributions

Conceptualization, Mengting Deng and Na Mao; methodology, Mengting Deng; software, Mengting Deng; validation, Mengting Deng, Linyu Xia, and Jing Xiong; formal analysis, Mengting Deng; investigation, Mengting Deng, Linyu Xia, Yaqin Peng, Yuanyuan Peng, and Jing Xiong; resources, Na Mao; data curation, Mengting Deng and Linyu Xia; writing—original draft preparation, Mengting Deng; writing—review and editing, Na Mao; visualization, Mengting Deng; supervision, Na Mao; project administration, Na Mao; funding acquisition, Na Mao. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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