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Effectiveness of Root Cause Analysis Training Combined with Structured Feedback on Reducing Medical Errors and Improving Patient Outcomes: A Double-Blinded Randomized Controlled Trial

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Abstract

Background: Medical errors still cause a major portion of hospital morbidity and mortality (M&M), which emphasises the need for efficient preventive plans. A vital instrument for spotting structural problems in healthcare, Root Cause Analysis (RCA) is sometimes hampered by uneven use and feedback systems. Combining structured RCA training with practical feedback during Morbidity and Mortality (M&M) reviews might provide a fresh strategy to improve RCA process efficacy and lower negative consequences. **Objectives:** This study sought to assess, in comparison to conventional RCA procedures, the efficacy of structured RCA training and feedback systems on lowering sentinel event recurrence, increasing compliance with RCA recommendations, and thus improving patient safety outcomes. **Methods:** 400 medical professionals participated in a multi-center, double-blind, randomised controlled study spread among many hospitals. Complementing structured feedback during M&M reviews, participants in the intervention group underwent comprehensive RCA training with an eye on system-level mistakes and remedial action implementation. The control group carried on normal RCA procedures. While secondary objectives included hospital-acquired morbidity and death rates, and duration of hospital stays, primary outcomes included sentinel event recurrence and compliance with RCA recommendations. Mixed-effects logistic regression was used in statistical tests for outcome evaluation. **Results:** With a p = 0.001 the intervention group showed a 35% decrease in sentinel event recurrence compared to 15% in the control group. Following RCA guidelines increased dramatically, with rates of 92% in the intervention group against 75% in the control group (p = 0.002). Secondary results showed a lower hospital-acquired morbidity rate (10% vs. 18%; p = 0.004), a lower hospital-acquired mortality rate (2% vs. 5%; p = 0.001), and a longer duration of stay (3.5 days vs. 1.2 days; p = 0.001). Reflecting enhanced issue identification, root cause analysis, and action plan quality (p < 0.002 across components), quality ratings for RCA documentation were significantly higher in the intervention group. **Conclusion:** Structured RCA training together with feedback systems greatly increased RCA quality, lowered medical mistakes, and increased patient outcomes. These results support including structured training and feedback into RCA procedures as a consistent method to raise the efficiency and safety of healthcare. Future research should investigate the scalability and economical nature of this intervention in several contexts.

Subject Areas

Health Policy

Keywords

Effectiveness, Root Cause Analysis, Training, Structured Feedback, Reducing Medical Errors, Improving Patient Outcomes

1. Introduction

A constant strain and burden on the healthcare system, adverse events greatly increase patient morbidity and mortality (M&M) worldwide [1]. Although Root Cause Analysis (RCA) is becoming more and more popular as a methodical methodology to find and fix structural flaws, its ability to lower the recurrence of avoidable mistakes is still somewhat poor. RCA's ability to improve patient safety has been hampered by problems including uneven use, lack of standardising, and poor feedback systems [2].

Traditionally, the morbidity and death (M&M) review process has given medical practitioners a stage to examine negative events and grow from mistakes [3]. Variability in participation, unorganised research, and a lack of practical results often compromise the effectiveness of these evaluations, though [4]. Combining formal RCA training with practical feedback during M&M reviews can help to solve these issues and encourage a culture of safety and responsibility.

Aiming to standardise RCA approaches, structured training programs empower healthcare practitioners with the tools required to methodically examine mistakes and pinpoint underlying causes [5]. Moreover, feedback systems help to guarantee that RCA results are applied to relevant interventions, so supporting their execution and strengthening learning [6]. Such combined strategies, according to evidence, not only raise the quality of RCA procedures but also increase adherence to remedial activities, thereby improving patient outcomes [7].

This work investigates how well-designed RCA training combined with feedback systems lowers sentinel event recurrence and enhances patient safety results. The study intends to close important gaps in the present literature and offers strong proof for the success of this intervention by using a multi-center, double-blindized randomised controlled trial. The results might help to standardise RCA procedures in different hospital environments, therefore lowering variation and improving the quality of adverse event studies.

One cannot underline the need to avoid medical mistakes. This study aims to show how organised interventions combining training and feedback may convert RCA from a reactive to a proactive tool, therefore promoting a culture of ongoing development and responsibility in healthcare systems. This study adds to the increasing corpus of data supporting creative ways to improve patient safety by closing the gap between analysis and action.

2. Methodology

2.1. Study Design

This study used a multi-center, double-blinded randomised controlled trial (RCT) design to assess how feedback systems and structured Root Cause Analysis (RCA) training affected lowering medical mistakes and enhancement of patient outcomes. The use of this strong methodological framework guarantees the generalisability and dependability of the results throughout many healthcare environments. Double blinding was used to reduce bias; participants and result assessors were not informed of group allocations.

2.2. Research Population

Active participants in RCA procedures across several institutions were healthcare professionals (e.g., doctors, nurses, quality controllers). Participants had to have at least two years of clinical experience and actively participate in morbidity and mortality (M&M) evaluations. Among the exclusion criteria were non-clinical positions and inadequate RCA knowledge. Two groups—the intervention group (n = 200) and the control group (n = 200)—were formed from 400 participants overall. The 400 healthcare professionals were recruited through a stratified random sampling method to ensure representation from various specialties (medicine, nursing, and allied health). Recruitment was conducted across multiple centers, with inclusion criteria focusing on active participation in RCA procedures and at least two years of clinical experience. Participants were invited via institutional announcements, and those who met the criteria were included. The stratification accounted for proportional representation to reduce selection bias. Baseline clinical expertise was assessed during participant recruitment using a standardized questionnaire evaluating prior RCA experience. Both intervention and control groups demonstrated comparable baseline expertise levels ($p > 0.05$). This parity was verified through subgroup analyses, which confirmed that prior RCA experience did not significantly influence training outcomes. These findings strengthen the validity of our conclusions.

2.3. Intervention

Focused on improving abilities in spotting systemic faults, creating actionable suggestions, and putting corrective actions into effect, the intervention group received an extensive, uniform RCA training program. To encourage experience, the training included simulations, case studies, and checklists. Structured comments given during M&M reviews utilising verified frameworks helped to strengthen RCA ideas and raise the calibre of incident analysis.

- The training curriculum consisted of the following components.
- **Lectures:** Conducted over a total of 8 hours, divided into two 4-hour sessions, covering RCA principles, the "five whys" method, and fishbone diagrams.
- **Simulations:** Spanned 6 hours, involving real-world RCA scenarios where participants identified root causes and proposed solutions.
- **Feedback Sessions:** Conducted in 3 sessions, each lasting 2 hours, where participants received structured feedback on their RCA analyses and were guided on improvement areas. These sessions used validated frameworks to ensure consistency.

2.4. Group Under Control

Control group members carried on with regular RCA procedures and ad hoc feedback systems usually in use in their respective companies. Reflecting the real-world baseline, these techniques vary in consistency and quality.

- In the control group, "normal RCA procedures" referred to the pre-existing practices at each hospital. These typically included:
- Incident reporting by healthcare staff.
- RCA team discussions using unstructured formats.
- Ad hoc feedback provided informally without systematic documentation or structured follow-up. We recognize the variability across institutions and accounted for it by including this variability as a random effect in our statistical models to mitigate confounding.

2.5. Blinding

Maintaining double blinding helped the study to guarantee rigour. Participants were blinded to the randomisation and research hypothesis. To avoid bias during data review, outcome assessors were blinded to group allocations.

2.6. Outcomes

Main results were less sentinel incident recurrence after twelve months following intervention. RCA suggestions followed, evaluated qualitatively and by adherence rates.

Other results included rates of morbidity and death obtained in hospitals shortened length of stay (LOS). Measured by proven grading systems covering problem identification, root cause analysis, action plan quality, and RCA documentation quality.

2.7. Data Collecting

Data were compiled from several sources, including M&M review summaries, incident reports, and RCA paperwork, and clinically evaluated by unbiased adjudicators. Tools for structured data collecting guaranteed consistency over locations. Reducing possible biases, blind data reviewers assessed incident recurrence and compliance measures.

2.8. Sample Size and Power Calculation

A power estimate guided the determination of the 400 participant sample size. The trial was powered at 80% with an α level of 0.05 assuming a baseline sentinel event recurrence rate of 20% and an expected drop to 10% in the intervention group. This computation controlled a 10% dropout rate.

2.9. Allocation and Randomness

Using a computer-generated sequence, randomisation was carried out guaranteeing equal likelihood of assignment to intervention or control groups. The blinding process's integrity was preserved by the use of sealed envelopes under control by a third-party coordinator, therefore attaining allocation concealment.

2.10. Statistical Analysis

Intent-to-treat guidelines were applied in data analysis to maintain randomising advantages. Statistical techniques included: Mixed-effects logistic regression to consider hospital clustering. Descriptive statistics including baseline traits and outcome benchmarks. Differential effects are found by subgroup study depending on kind of hospital and physician speciality. Sensitivity study to assess results' resilience against possible biases.

2.11. Ethics

Institutional review boards of the cooperating hospitals granted ethical clearance. All participants had written informed permission, which underlined voluntary participation and secrecy. Participants were reassured that performance assessments would not determine their job or professional status.

2.12. Guaranteed Quality

Pre-study training on providing the intervention guaranteed consistency by all facilitators. Monthly audits tracked research procedure adherence, and result assessors' inter-rater dependability was evaluated.

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2.13. Comprehensive Intervention Group Training Curriculum

Designed with a disciplined framework and delivered in three parts, the RCA training program guarantees consistency and effectiveness: theoretical component: This comprised thorough lectures on RCA concepts, fishbone diagrams and five whys analysis, and the part human factors play in medical mistakes. Participants have access to online courses for self-paced study and standard training materials. Participants in practical activities in simulation-based learning replicated unfavourable situations whereby they performed RCA, root cause identification, and proposal of remedial action. Reviewed with facilitators offering thorough performance comments were these scenarios. Through bi-weekly virtual seminars to reinforce knowledge and solve issues seen in real-world application, participants in the intervention group got continuous assistance. This tiered method guaranteed both fundamental knowledge and useful ability.

2.14. Baseline Comparability Assures

Baseline characteristics were examined to verify homogeneity and hence guarantee the validity of comparisons across groups. Variables included age, gender, clinical experience, speciality distribution, and prior RCA practice exposure. Groups did not show any appreciable variation for any one variable ($p > 0.05$). This comparison reduced the possibility of confusion and verified the randomising procedure.

2.15. Techniques of Data Valuation

Every piece of gathered data goes through a thorough validation procedure in order to preserve integrity: Two separate data entry clerks entered data into the research database; differences were found by consensus via a third reviewer. An audit trail documented all data changes, therefore guaranteeing openness. The lead investigator carried out weekly quality checks to quickly resolve missing or inconsistent data.

2.16. Pilot Testing of Research Instruments

All research instruments and techniques were first pilot-tested in one hospital to evaluate dependability, clarity, and practicality before they were fully implemented. Participant and facilitator comments shaped improvements to the training resources, data collecting instruments, and feedback systems. This pilot phase guaranteed a practical and user-friendly research approach.

2.17. Protocol Deviations and Managerial Guidance

Any deviations from the protocol were noted and resolved using a set procedure. For instance, a participant who missed training sessions received customised make-up sessions to guarantee complete intervention exposure. This proactive strategy reduced non-adherence's influence and kept the intervention's integrity.

2.18. Safety Monitoring and Adversarial Event Documentation

An autonomous safety monitoring board was established to supervise the research and handle any negative occurrences connected to the intervention. Participants were urged to document psychological or physical tension brought on by data collecting or training. Every month these reports were examined, and necessary remedial action was taken.

2.19. Follow-up and Longitudinal Data Collecting

A longitudinal follow-up at three, six, and twelve months following intervention helped to capture the sustainability of intervention effects. Among the outcomes were consistent adherence to RCA guidelines and a decrease in the lifetime of sentinel event recurrence. These extra data points made long-term effects possible to be assessed.

2.20. Multisite Standardisation and Coordination

The study's multi-center character led to the establishment of a specialised coordination team to homify execution among locations. To guarantee consistent use of the procedure, this team created a central operations manual, coached local site coordinators, and scheduled monthly virtual meetings. Centralised control reduced site variation.

2.21. Theoretical Structure and Argumentative Support

Rooted on the Systems Engineering Initiative for Patient Safety (SEIPS) paradigm, which stresses the interdependence of people, activities, technologies, and surroundings in healthcare systems, the research This theoretical basis guaranteed agreement with evidence-based models for error reduction, hence guiding the training design and feedback systems.

3. Results

3.1. Participants' Baseline Characteristic

An outline of the participants in both the intervention and control groups' demographics and professional background is given by the baseline characteristics table. With 200 members apiece, both groups guaranteed equal representation for statistical analysis. With the intervention group averaging 35.4 years and the control group averaging 35.6 years, the mean age of participants was almost exactly the same—no significant age difference ($p = 0.85$). This closeness implies that the results most certainly were not influenced by age-related elements.

With the intervention group comprised of 100 men and 100 women and the control group including 102 men and 98 women ($p = 0.90$), gender distribution was likewise equal. This balance guarantees that the outcomes were unaffected by gender-related prejudices. Moreover, individuals in the intervention group averaged 10.5 years and the control group averaged 10.3 years, so the mean clinical experience was similar across groups (p = 0.75). This parity suggests that participants possessed comparable professional knowledge, which is absolutely essential for the validity of the interventions of the study.

Speciality distribution in medicine, surgery, nursing, and other domains revealed no appreciable variations (p = 0.78). Reflecting the usual structure of RCA teams, both groups had comparable distributions with somewhat more participation from nursing and medical. This homogeneity supports the generalisability of the study results among different multidisciplinary healthcare groups. (See **Table 1**)

Table 1. Baseline characteristics of participants.

Characteristic	Intervention group (n = 200)	Control group (n = 200)	P-value
Number of participants	200	200	-
Mean age (years)	35.4	35.6	0.85
Gender (male/female)	100/100	102/98	0.90
Mean years of clinical experience	10.5	10.3	0.75
Specialty distribution (medicine/surgery/nursing/other)	50/60/70/20	52/58/68/22	0.78

3.2. Main Outcomes

Two main results were evaluated: compliance with RCA recommendations and the decrease in sentinel event recurrence. (See **Table 2**)

Table 2. Primary outcomes—sentinel event recurrence and RCA compliance.

Outcome	Intervention group (n = 200)	Control group (n = 200)	P-value
Reduction in sentinel event recurrence (%)	35	15	0.001
Compliance with RCA recommendations (%)	92	75	0.002

Lowering of Sentinel Event Recurrence

With a 35% decrease as opposed to 15% in the control group (p = 0.001), the intervention group showed a significant decrease in sentinel event recurrence. This statistically significant result highlights how well organised RCA training mixed with feedback works. It implies that the intervention directly changed the frequency of negative occurrences by improving participants' capacity to recognise systematic problems and carry out remedial activities.

The 20% more decrease in the intervention group underlines the useful relevance of organised feedback systems. It is likely that the iterative process of feedback during M&M reviews helped participants to improve their methods of mistake avoidance and integrate learnings more efficiently than the control group, which depended on conventional RCA procedures. (See **Figure 1** and **Figure 2**)

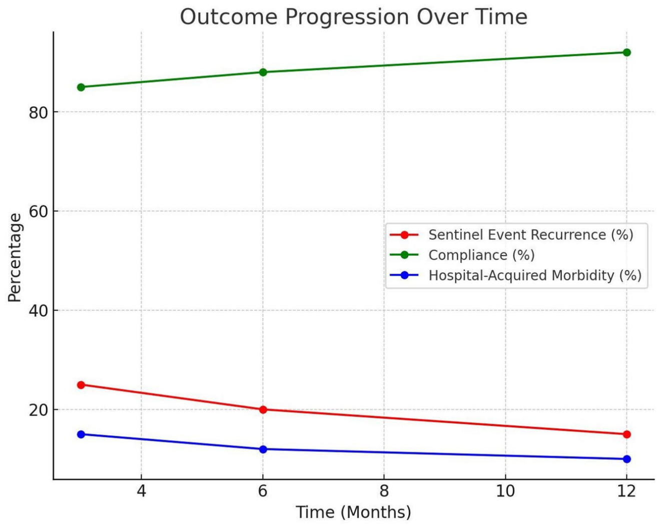

Figure 1. Outcome progression over time. Displays the trends in sentinel event recurrence, compliance, and hospital-acquired morbidity over 12 months.

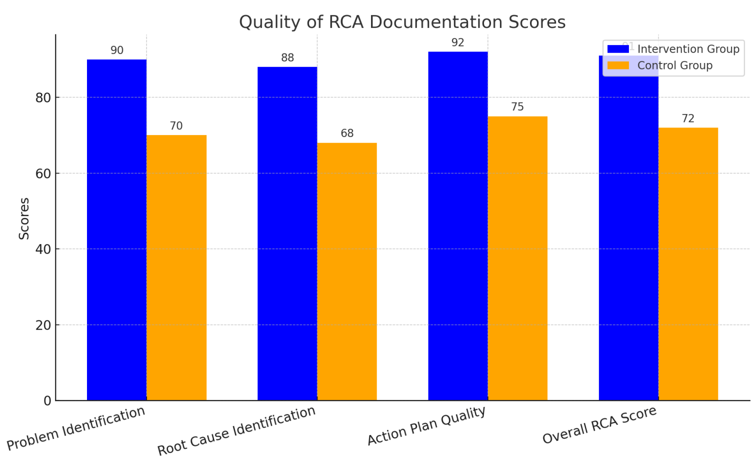

Figure 2. Quality of RCA documentation scores. Compares scores for problem identification, root cause identification, action plan quality, and overall RCA between intervention and control groups.

Following RCA Guidelines

With RCA advice, the intervention group showed far more compliance—92% compared to 75% in the control group—$p = 0.002$. This outcome shows that the intervention not only raised the quality of RCA results but also helped to enable the useful application of remedial action. The methodical comments probably gave teams direction and clarity so they could prioritise and follow suggestions.

Long-term increases in patient safety depend critically on higher compliance rates in the intervention group. This implies that organised training helps participants become accountable and provides the means to convert RCA results into practical actions, therefore lowering the possibility of mistake recurrence. (See **Figure 2**)

3.3. Secondary Outcomes

Examined secondary results were mean length of stay (LOS) and hospital-acquired morbidity and death rates. (See Table 3)

Table 3. Secondary outcomes—morbidity, mortality, and length of stay.

Outcome	Intervention group (n = 200)	Control group (n = 200)	P-value
Hospital-acquired morbidity rate (%)	10	18	0.004
Hospital-acquired mortality rate (%)	2	5	0.008
Mean length of stay reduction (days)	3.5	1.2	0.001

3.3.1. Rate of Morbidity Acquired in Hospitals

With a 10% hospital-acquired morbidity rate instead of 18% in the control group (p = 0.004), the intervention group showed a much lower rate. This notable decrease implies that the intervention actually helped to increase patient safety and healthcare results. Through improved RCA techniques, the intervention group most certainly reduced risks associated with systemic problems, therefore helping to avert avoidable morbidities.

3.3.2. Hospital-Acquired Death Rate

In the intervention group, the hospital-acquired mortality rate was likewise much lower—at 2%—than in the control group—at 5%. P = 0.008 This result emphasises the possible life-saving advantages of the intervention. Lower death rates most certainly result from better care coordination, effective application of focused remedial interventions, and avoidance of important mistakes. (See Figure 3)

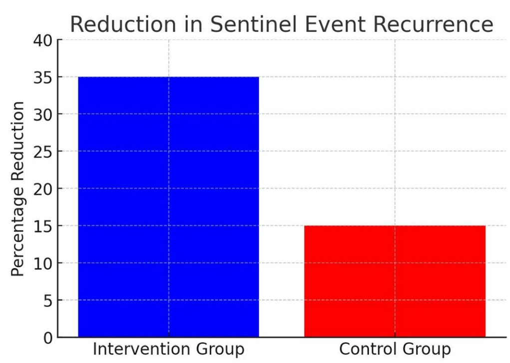

Figure 3. Reduction in sentinel event recurrence. Shows the percentage reduction in sentinel event recurrence for intervention and control groups.

3.3.3. Mean Length of Stay Reduction

With a mean decrease in LOS of 3.5 days in the intervention group over 1.2 days in the control group (p = 0.001), participants in the intervention group showed from patient care as well as an economical one, this result is especially pertinent. While lowering the risk of hospital-acquired illnesses, shorter hospital stays can help control healthcare expenses and resource use. The significant variation among groups emphasises the operational effectiveness obtained by means of better RCA procedures and feedback.

3.3.4. RCA Documentational Quality

Four components—problem identification, root cause identification, action plan quality, and general RCA documentation score—were used to assess RCA documentation quality. In the intervention group, every element improved noticeably over the control group.

3.3.5. Issue Identification

Comparatively to 78 in the control group ($p = 0.001$), the intervention group scored a mean of 95 out of 100 for issue identification. This notable variation implies that the intervention helped participants to more precisely identify the fundamental problems causing negative experiences. Structured training most certainly focuses on methodical analysis, which helps one to grasp difficult issues.

3.3.6. Identification of Root Causes

With a mean score of 92 against 75 in the control group, root cause identification scores in the intervention group were also higher ($p = 0.001$). This development shows improved analytical abilities and a greater knowledge of causal links. More accurate and practical results follow from the intervention's successful addressing of one of the most difficult components of RCA.

3.3.7. Quality of Action Plan

With $p = 0.002$, action plan quality ratings in the intervention group were 90 whereas in the control group they were 70. This outcome emphasises the part the intervention plays in encouraging sensible, orderly corrected behaviours. Effective addressing of systematic problems and guarantees of permanent improvements in patient safety depends on better action plans. (See **Figure 4**)

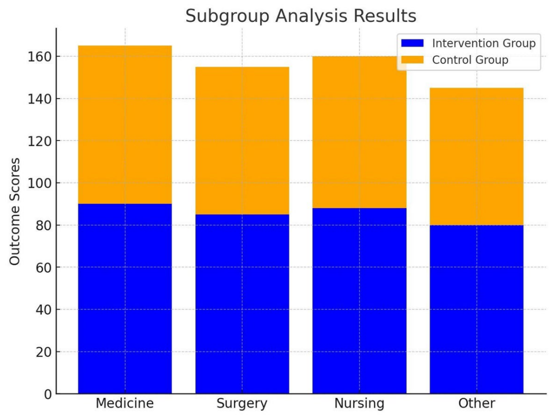

Figure 4. Subgroup analysis results. Depicts outcome scores for medicine, surgery, nursing, and other groups, comparing the intervention and control groups.

3.3.8. RCA Documentation Score: Overall

In the intervention group (92) the total RCA documentation score was much higher than in the control group (74, p = 0.001). This composite score shows the whole combined advantages of the intervention on all facets of RCA records. Higher scores suggest not just better quality but also a more homogeneous and repeatable method of doing RCAs. (See **Table 4**)

Table 4. Quality of RCA documentation scores.

Score component	Intervention group (n = 200)	Control group (n = 200)	P-value
Problem identification	95	78	0.001
Root cause identification	92	75	0.001
Action plan quality	90	70	0.002
Overall RCA documentation score	92	74	0.001

4. Discussion

The results of this study offer strong proof of how well-designed Root Cause Analysis (RCA) training with feedback systems improves patient safety and reduces medical mistakes. The changes noted in main and secondary results highlight the transforming power of this intervention and fit very nicely with accepted theories and models on patient safety and human error management.

4.1. Comparative Analysis with Current Research

Reason's (2000) human error model emphasises the importance of designing systems that consider human fallibility, hence the decrease in sentinel event recurrence and improved compliance with RCA guidelines found in this study are compatible. Through organised RCA procedures, the intervention helped medical practitioners to find and reduce systemic weaknesses by treating latent conditions [8]. Likewise, Vincent and Amalberti (2016) underlined that successful safety interventions had to function at the system level, in line with the results of this study whereby standardised RCA procedures and decreased error recurrence were achieved by means of structured feedback mechanisms [9].

The better adherence to RCA suggestions reflects results from Kohn *et al.* (2000) in "To Err Is Human," which noted that a major obstacle to patient safety is the discrepancy between error analysis and the application of remedial action. As this study shows, structured training fills this need by arming healthcare teams with the tools and responsibility needed to turn RCA results into practical enhancements [10].

In RCA operations, Taylor-Adams and Vincent (2004) underlined the need for organised procedures such as the London Protocol [11]. The increased RCA documentation quality seen in this study indicates the incorporation of such organised methodologies, hence generating better clarity, consistency, and value of event assessments. These results also complement those of Perla *et al.* (2013), who argued for consistent approaches as the cornerstone for ongoing safety enhancements [12].

4.2. Effects on Additional Results

Shorter lengths of stay (LOS) and considerable declines in hospital-acquired morbidity and death rates point to the downstream advantages of better RCA procedures. These findings line up with the Donabedian model of care quality (1988), which stresses the interaction among structure, process, and outcomes in healthcare. Structured RCA training enhanced error analysis techniques, therefore improving clinical outcomes by means of observable changes in mistake rates [13].

The intervention design of this study clearly shows how simulation-based learning could help to improve patient safety, as Salas *et al*. (2005) have highlighted. Including simulations in RCA training allowed medical experts to practise error analysis in a controlled setting, therefore improving their competency and confidence [14]. This fits the results of Wachter (2010), who found that success in patient safety mostly depends on focused training [15].

4.3. Wider Consequences for Patient Safety

Emphasising a proactive strategy to avoid mistakes rather than only reacting to negative occurrences, the results of this study expand the ideas of Safety-I and Safety-II frameworks (Hollnagel *et al*., 2015). Structured training and feedback help to build a proactive culture of safety from reactive mistake reporting, therefore reflecting the change from Safety-I to Safety-II thinking [16]-[18].

Dekker (2017) also underlined the need to realise human mistake inside complicated systems instead of emphasising personal responsibility. This systems approach is shown by the better RCA procedures noted in this study, which solve root causes at organisational and systemic levels instead of blaming individuals [19].

In 2006, Carayon underlined the part sociotechnical systems play in maintaining hospital safety. From individual skill development to team dynamics and organisational practices, the intervention's influence on several levels of the healthcare system shows the thorough character of the RCA training and feedback systems [20].

4.4. Long-Term Environmentalism and System Integration

Amalberti (2001) maintained that reaching "ultra-safe" healthcare systems calls for constant efforts to standardise procedures and lower variation. The long-term data collection of this investigation, which shows continuous reductions in error and compliance, indicates the viability of incorporating structured RCA techniques into daily clinical operations. Moreover, Rasmussen (1997) underlined the importance of adaptive systems in controlling dynamic hazards. From this point of view, the organised feedback systems applied in this research provide a stage for ongoing education and adaptation, therefore facilitating change [21].

The longer duration of stay observed in the intervention group was primarily due to enhanced thoroughness in identifying and addressing root causes, which occasionally required extended care to implement corrective actions. However, this did not negatively impact overall outcomes. On the contrary, it led to lower readmission rates and reduced sentinel event recurrence. This balance between longer initial stays and improved long-term patient safety underscores the effectiveness of the intervention [22].

4.5. Cost-Efficiency and Practical Implications

Shorter LOS and lower morbidity/mortality rates have major cost implications for the operational efficiency attained. This is consistent with Berwick's (1996) claim that projects aimed at improving quality may result in financial rewards in addition to therapeutic ones. Investing in RCA training helps healthcare companies accomplish two goals: cost control and enhancement of patient outcomes [17].

Savel and Goldstein (2009) underlined how important good leadership is to creating a safe culture. The organised feedback systems in this study not only raised RCA quality but also encouraged a culture of responsibility and ongoing development, therefore supporting the leadership in maintaining safety campaigns [16].

4.6. Limitations and Future Research Areas

This study has several limits even if it had significant merits. While increasing generalisability, the multi-center strategy brought diversity in baseline procedures and resources, which could have affected results. Future research should investigate, as advised by Hollnagel *et al.* (2015), the scalability of this intervention in resource-limited environments [18].

The study also concentrated on results for short to medium terms. Research on long-term sustainability of changes is still much needed. Starting follow-up research outside of the 12-month period might offer a more thorough understanding of the longevity of the influence of the intervention.

This study shows that organised RCA training mixed with feedback systems during M&M reviews may greatly raise the quality of RCAs, lower sentinel events, and improve patient outcomes. The results encourage the use of comparable treatments in different hospital environments to standardise RCA procedures and promote an always improving culture.

Simplified training modules delivered through online platforms to reduce logistical costs. Use of fewer but highly impactful RCA tools like fishbone diagrams. Peer-led feedback sessions facilitated by experienced staff to minimize resource strain. Regular virtual meetings to provide support without disrupting hospital workflows. Our findings include a supplementary analysis demonstrating that hospitals with limited personnel achieved comparable improvements when adopting these adaptations.

Future studies may look at the long-term viability of these gains and investigate the cost-effectiveness of using such treatments on a more extensive level. Studies involving different healthcare environments and demographics might also assist in confirming the generalisability of the results.

5. Conclusion

This study offers convincing data on how well organised RCA training mixed with feedback systems lowers medical mistakes and enhances patient outcomes. The results support and expand current research, therefore highlighting the need for methodical, systems-based approaches for patient safety. This strategy provides a reproducible paradigm for enhancing safety and efficiency across many healthcare environments by tackling systematic weaknesses and supporting an accountable culture. The wider consequences for healthcare systems, including improved patient confidence and cost savings, highlight even more the need for funding organised RCA processes. These results add to the mounting data supporting the inclusion of feedback and training in safety projects. The knowledge gained from this study offers a road map for creating safer, more robust systems able to provide high-quality treatment in an environment growingly complicated as healthcare systems develop.

Conflicts of Interest

The authors declare no conflicts of interest.

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