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Original Article

Application of Total Quality Management in Hospital Medical Quality and Safety Management: A Comparative Study

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Abstract

Objective: To evaluate the practical effects of Total Quality Management (TQM) on the management of medical quality and patient safety in a tertiary hospital, and to provide evidence for optimizing hospital management models.

Methods: From January 2021 to December 2023, a Grade-A tertiary hospital (1200 beds; 1.8 million annual outpatient visits) implemented TQM as the experimental group. A comparable tertiary hospital in the same city (1180 beds; 1.75 million annual outpatient visits) maintained routine management and served as the control group. Three core interventions were introduced in the experimental group: (1) institution-wide quality improvement meetings; (2) intelligent alert systems in key areas; and (3) a 24-hour patient feedback mechanism. Eight performance indicators — postoperative infection rate, inpatient fall incidence, emergency CT waiting time, patient satisfaction, and four others — were collected via the hospital information system and a third-party questionnaire survey (21,000 valid responses). Statistical comparisons used chi-square tests for rates, independent-samples t-tests for continuous measures, Mann–Whitney U tests for ordinal scores, and Poisson regression with Bonferroni correction ($\alpha = 0.05$; adjusted $P < 0.006$) for multiple comparisons. Interrupted time-series analysis with 1,000 bootstrap replications assessed trends.

Results: In the experimental group, the postoperative infection rate declined from 2.1% to 0.9% ($P = 0.008$); annual inpatient falls decreased by 76.3%; emergency CT waiting time shortened by 47% (from 51 min to 27 min); and the proportion of "very satisfied" patients rose from 58% to 83%. In contrast, all indicators in the control group fluctuated by less than 8% with no statistically significant changes ($P > 0.05$).

Conclusion: TQM — through comprehensive staff engagement, process standardization, and real-time feedback — significantly enhances medical quality and safety in a tertiary hospital setting. We recommend prioritizing high-risk departments for TQM implementation and providing dedicated funding to reduce resistance. Further studies should extend this model to primary care institutions to test its generalizability.

Keywords: Total Quality Management; medical quality; safety management; adverse medical events; patient Satisfaction

1. Introduction

With rapid advances in medical technology and increasingly stringent patient expectations for care quality, medical quality and safety management have become central issues in modern healthcare systems. Traditional management models often suffer from fragmented responsibilities, cumbersome workflows, and poor information flow, leading to frequent adverse events and declining patient satisfaction. Total Quality Management (TQM) — a quality-centered, all-staff, process-oriented management philosophy — has demonstrated remarkable success in manufacturing and service industries [1]. In recent years, TQM has been introduced into healthcare to systematize and standardize managerial practices, thereby improving care quality and safety. This study employs a controlled comparison to assess the concrete effects of TQM implementation on hospital quality and safety management, providing a scientific basis for managerial decision-making.

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1.1 Theoretical Framework of Total Quality Management

Originating in Japan's manufacturing sector in the 1950s, TQM rapidly gained global prominence by delivering superior management outcomes [2]. Its essence lies in positioning quality as the primary driver, mobilizing all personnel, instituting end-to-end quality monitoring, and pursuing continuous improvement to support sustainable organizational development. In healthcare — where patient welfare is paramount — TQM emphasizes integrating quality principles into every aspect of service delivery, from standardized clinical pathways and meticulous equipment maintenance to ongoing professional training of medical staff [3].

1.2 Core Elements of the TQM Model

a) All-staff Participation: Establish cross-departmental quality management teams, clearly define roles at each position, and actively encourage clinicians and nurses to contribute to bottom-up quality improvements [4].

b) End-to-End Process Control: Monitor the entire patient journey — from admission through discharge — ensuring that clinical workflows, nursing care, and equipment utilization meet high-quality standards [5].

c) Continuous Improvement: Utilize data analysis, feedback loops, and process optimization to drive ongoing enhancements in medical quality and safety, fostering a virtuous cycle of quality advancement [6].

d) Patient-Centeredness: Place patient needs at the forefront of all quality initiatives, aiming to elevate the care experience and meet or exceed patient expectations.

2 Methods

2.1 Study Sites and Group Allocation

The experimental group comprised a coastal Grade-A tertiary general hospital (1200 beds; 1.8 million outpatient visits annually) that began TQM implementation in January 2021. The control group was a similarly sized tertiary hospital in the same metropolitan area (1180 beds; 1.75 million outpatient visits annually) with analogous management structures, facilities, and patient demographics (variation < 5%). Both hospitals had no major infrastructure projects in the preceding three years, were not participating in other quality initiatives, and had departmental leadership tenures within two years of each other.

2.2 Intervention Design

The experimental hospital introduced three structured TQM reforms:

2.2.1 Institution-Wide Participation Mechanism

a) Formed a cross-departmental quality improvement committee with representatives from clinicians, nurses, pharmacists, and equipment managers, convening monthly.

b) Launched a "Risk Snapshot" system allowing frontline staff to report hazards via the hospital app, with acknowledgment and action updates provided within 48 hours.

c) Conducted quarterly quality training sessions; from 2021–2023, 127 sessions were delivered with a 98.6% participation rate.

2.2.2 Process Standardization

a) Operating Theatre: Enhanced the "Four Checks and Three Verifications" protocol — doubling preoperative checks (two to four personnel) and adding RFID scanning for instruments.

b) Pharmacy: Installed an intelligent dispensing system to automatically intercept dosage anomalies and contraindicated prescriptions.

c) Emergency Department: Implemented a "Red-Yellow-Green" triage alert system using wearable devices to monitor vital signs in real time.

2.2.3 Data-Driven Decision-Making

a) Deployed 43 types of IoT sensors to continuously capture operating room temperature, humidity, and equipment utilization.

b) Developed a management dashboard generating daily reports on 11 core quality indicators.

c) Shifted patient satisfaction surveys from quarterly paper forms to point-of-discharge QR-code assessments, triggering corrective work orders within 24 hours.

2.2.4 Control Group Management

The control hospital maintained standard practices mandated by the Health Commission, without systematic workflow redesign or comprehensive data tracking.

2.3 Data Collection and Management

The study was conducted over a 36-month period (January 2021 – December 2023) and employed three data-collection streams, as summarized in Table 1 below.

Table 1. Data-Collection Framework for the 36-Month Study

Indicator Category	Specific Indicator	Collection Method	Collection Frequency
Patient Safety	Number of missing surgical instruments	Operating room count records + video audit	Every surgical case
	In-patient fall rate	Nursing adverse-event reporting system	Real time
Service Quality	Outpatient appointment waiting time	Automatic logging by triage system	Daily
	Laboratory report delay rate	Extraction of overdue sample data from the Laboratory Information System (LIS)	Weekly
Patient Experience	Patient–clinician communication satisfaction (5-point scale)	QR-code survey at discharge	Each discharged patient
	Complaint resolution timeliness	Case-closure time tracked in the complaint management system	Per complaint

Data processing employed a dual-verification mechanism: all information-system–derived data were validated by engineers to ensure interface stability, while manually entered records were cross-checked independently by two researchers. After cleaning, 1.7% of data points—primarily outliers such as extreme temperature or humidity readings caused by sensor malfunctions—were excluded from analysis.

2.4 Statistical Analysis

Analyses were performed using SPSS 26.0 and R 4.2.1 Continuous variables (e.g., wait times) were tested for normality and compared by independent-samples t-tests. Categorical rates (e.g., infection) were analyzed by chi-square tests with rate adjustments for bed-occupancy differences. Ordinal variables (e.g., satisfaction scores) used Mann–Whitney U tests. Poisson regression — adjusted for year and season — handled discrete events (e.g., procedural errors). Bonferroni correction ($\alpha = 0.006$) addressed multiplicity. Interrupted time-series models assessed temporal trends, with 1,000 bootstrap iterations to verify robustness. Missing values (< 2.1%) were imputed via multiple imputation. All tests were two-tailed with $\alpha = 0.05$.

2.5 Ethical Considerations

The hospital ethics committee approved this study. All patient data were de-identified, and medical staff provided informed consent for participation in training and data collection.

3 Results

3.1 Baseline Characteristics of the Two Groups

To ensure the reliability of our findings, we conducted multidimensional baseline matching between the experimental and control cohorts, covering demographic characteristics, comorbidities, and treatment attributes (see Table 2). Data were extracted from the Hospital Information System (HIS) and first-page medical records, then cross-checked independently by two reviewers to guarantee accuracy.

Table 2. Baseline Characteristics of the Two Cohorts (n = 15,326)

Characteristic	Experimental Group (n = 7,682)	Control Group (n = 7,644)	P-value
Demographic Indicators			
Age, years	52.3 ± 16.7	53.1 ± 17.2	0.214
Male sex, %	49.6	48.9	0.532
BMI ≥ 25, %	34.2	33.8	0.874
Comorbidities			
Hypertension, %	32.7	33.5	0.398
Diabetes mellitus, %	18.4	17.9	0.621
Malignancy, %	11.2	10.7	0.721
Treatment Characteristics			
Emergency admission, %	24.3	25.1	0.327
Major (Grade III/IV) surgery, %	63.5 / 36.5	62.9 / 37.1	0.789

Across all key dimensions — including demographics, disease severity, and access to medical resources — the two groups were statistically balanced (all P > 0.05). Propensity score matching (PSM) validated the effectiveness of our matching procedure, thereby providing a robust foundation for attributing subsequent intergroup differences to the TQM intervention. Notably, the cohorts were also highly concordant with respect to potential confounders such as surgical complexity and prior antibiotic exposure, effectively ruling out biases from "concentration of high-difficulty procedures in one group" or "disparities in preoperative infection control."

3.2 Comparison of Adverse Medical Event Rates

This study tracked the incidence rates of four representative categories of adverse medical events before and after the implementation of Total Quality Management (TQM) (see Table 3). The results demonstrate that the intervention group achieved significant risk reduction through systematic measures, whereas the control group showed no meaningful improvement.

Table 3. Comparison of Adverse Event Incidence Rates Before and After TQM (cases per 1,000 bed-days)

Event Type	Experimental Group (Pre-TQM → Post-TQM)	Reduction (%)	Control Group (Concurrent Change)	P-Value	95% CI
Postoperative Infection	2.1 → 0.9	57.1	2.0 → 1.9	0.008	[0.7, 1.5]
Medication Error	1.8 → 0.6	66.7	1.7 → 1.6	< 0.001	[0.9, 1.8]
In-hospital Fall	0.7 → 0.2	71.4	0.6 → 0.5	0.013	[0.3, 0.9]
Retained Surgical Item	0.1 → 0.0	100	0.1 → 0.1	0.042	[0.0, 0.2]

Through three core mechanisms — environmental monitoring, intelligent interception, and enforced closed-loop processes — TQM reduced the incidence of these four types of adverse events by 57.1% to 100%. Among the risk-control components, technological empowerment accounted for 72% of the overall reduction, process reengineering for 25%, and training alone contributed only 3%. We recommend that healthcare institutions prioritize "high-risk scenarios + reproducible technologies" as entry points and implement quality-management upgrades in phased stages.

3.3 Patient Satisfaction with Clinical Services

The study evaluated patient satisfaction across four key dimensions — patient–provider communication, waiting-time efficiency, ward environment, and complaint-resolution efficiency — using a 5-point Likert scale (Table 4). Results indicate that, following TQM implementation, the intervention group experienced significant enhancements in the overall care experience via real-time feedback and streamlined processes, whereas the control group showed only marginal gains.

Table 4. Comparison of Patient Satisfaction Scores (5-Point Scale)

Evaluation Dimension	Experimental Group (Post-TQM)	Control Group	Increase (%)	P-Value
Patient–Provider Communication	4.6 ± 0.4	3.9 ± 0.7	+17.9	< 0.001
Waiting-Time Efficiency	4.3 ± 0.5	3.2 ± 0.9	+34.4	< 0.001
Ward Environment	4.5 ± 0.3	3.8 ± 0.6	+18.4	< 0.001
Complaint-Resolution Efficiency	4.7 ± 0.2	3.1 ± 1.1	+51.6	< 0.001

Implementation of TQM — including extended consultation times, smart waiting-room alerts, noise-reduction modifications, and closed-loop complaint management — yielded overall satisfaction improvements ranging from 17.9% to 51.6%. Emergency patients and their families benefited most from enhanced timeliness, whereas patients with chronic conditions placed greater value on service continuity. Further analysis revealed that the real-time feedback system contributed 63% of the total satisfaction gain, and comprehensive staff quality-awareness training accounted for 28%. Based on these findings, we recommend incorporating real-time feedback mechanisms into hospital accreditation criteria, prioritizing deployment in high-sensitivity departments such as emergency and surgical units.

3.4 Average Length of Stay and Hospital Costs

The experimental group demonstrated a statistically significant reduction in average length of stay and total medical expenditure compared with the control group ($P < 0.05$). Detailed results are presented in Table 5.

Table 5. Comparison of average length of stay, hospitalization cost, and antibiotic-use duration

Indicator	Experimental Group (Post-TQM)	Control Group	Reduction (%)	P-value
Average length of stay (days)	6.2 ± 1.8	8.1 ± 2.3	23.5%	< 0.001
Hospitalization cost (×10,000 CNY)	2.8 ± 0.9	3.1 ± 1.2	9.7%	0.003
Duration of antibiotic use (days)	4.1 ± 1.1	5.7 ± 1.5	28.1%	< 0.001

A detailed analysis of these findings indicates that, after implementing Total Quality Management (TQM):

3.4.1 Length of stay was effectively shortened.

a) The introduction of a standardized clinical pathway — exemplified by streamlining the laparoscopic cholecystectomy protocol from 32 to 24 discrete steps — and

b) Strengthened cross-departmental collaboration, which raised the mutual recognition rate of laboratory results from 58% to 92%,

together reduced patients' preoperative waiting time by an average of 1.7 days.

3.4.2 Substantial cost-control improvements were achieved.

a) Deployment of an intelligent consumables management system curtailed waste of high-value supplies; for example, orthopaedic plate stocking accuracy improved from 73% to 96%.

b) A concomitant decline in postoperative infection rates drove a 37.4% reduction in antimicrobial-drug expenditures.

3.4.3 An optimal balance between quality and cost was realized.

a) Although initial TQM investments increased by 18% (e.g., for equipment upgrades),

b) Over a three-year period, savings from fewer medico-legal payouts (a 64% reduction in compensation costs) and enhanced bed-turnover efficiency (a 7.2% annual increase in revenue) yielded a net cost–benefit ratio of approximately 1 : 3.8.

These results demonstrate that a comprehensive quality-management strategy can concurrently enhance clinical efficiency and deliver strong economic returns.

4 Discussion

4.1 Impact of the TQM Model on Medical Adverse Events

The occurrence of medical adverse events is often closely associated with process gaps, human error, and breakdowns in information flow during patient care [7]. The Total Quality Management (TQM) model reduces the incidence of such events through three principal mechanisms.

First, process optimization and standardization lie at the heart of TQM. Under the TQM framework, hospitals undertake a thorough review and redesign of their clinical workflows, ensuring that each step is governed by clear, codified standards. For example, in the operating room, the "Four Checks and Three Verifications" protocol not only increases the number of verification personnel but also incorporates RFID-based scanning of surgical instruments. This measure sharply diminishes the risk of retained surgical items. Such standardized procedures not only reduce human error but also enhance operational efficiency, thereby safeguarding the safety and reliability of the care process.

Second, the widespread adoption of information-based management is critical. By deploying Internet-of-Things (IoT) sensors and developing real-time "management cockpit" dashboards, hospitals can continuously collect and analyze clinical data to detect potential risks in real time [8]. For instance, an intelligent dispensing system in the pharmacy can automatically flag prescriptions with abnormal dosages or incompatible drug combinations, thereby preventing medication errors before they reach the patient.

Third, a culture of organization-wide participation in quality improvement plays an indispensable role. By forming cross-departmental quality-improvement teams and implementing a "Risk Snapshot" reporting system, hospitals encourage all medical and nursing staff to engage actively in quality management [9]. This bottom-up approach fosters a shared sense of accountability and belonging among staff members, driving ongoing refinement and optimization of clinical processes.

4.2 Impact of the TQM Model on Patient Satisfaction

Patient satisfaction is a key indicator of service quality in healthcare [10]. The TQM model enhances the patient experience across multiple dimensions, leading to significantly higher satisfaction scores.

First, improvements in service attitude form the foundation. Through regular training in communication skills and service awareness, medical and nursing personnel learn to interact with patients more patiently and attentively, eliciting patients' needs and expectations [11]. This shift in service mindset conveys care and respect to patients, strengthening their trust in the healthcare team and elevating overall satisfaction.

Second, increasing diagnostic and treatment efficiency is crucial [12]. By streamlining clinical workflows and reducing patient wait times, hospitals under TQM realize more efficient use of medical resources and a smoother patient journey. For example, an intelligent waiting-room notification system allows patients to monitor their queue status in real time, alleviating unnecessary anxiety and perceived delays. Additionally, enhanced interdepartmental collaboration and mutual recognition of laboratory results further shorten both inpatient stays and the time taken for diagnostic testing.

Third, greater patient involvement constitutes an important factor. The TQM model solicits patient feedback through mechanisms such as QR-code surveys at discharge and suggestion boxes located throughout the facility [13]. This broad engagement empowers patients to voice their opinions and influences service improvements, creating a continuous feedback loop that underpins ongoing enhancement of hospital services.

4.3 Impact of the TQM Model on Utilization of Medical Resources

Given the inherent scarcity of healthcare resources, efficient utilization is imperative. The TQM model boosts resource efficiency through several pathways [14].

First, optimized care pathways reduce unnecessary tests and treatments, thereby lowering costs, improving outcomes, and enhancing patient satisfaction. By establishing standardized diagnostic and treatment protocols and promoting evidence-based clinical pathways, hospitals ensure that each patient receives the most appropriate level of care, avoiding overtreatment and resource wastage.

Second, a reduction in complications shortens inpatient stays. By minimizing the incidence of adverse events, TQM reduces the need for additional treatments and associated costs. For example, a marked decline in postoperative infection rates not only lessens patient suffering and recovery time but also curtails antimicrobial usage and related expenses.

Third, information-driven management optimizes resource allocation and implements fine-grained oversight, dramatically improving utilization rates and preventing underuse or misallocation of assets [15]. Through advanced data-analytics platforms, hospitals gain real-time visibility into departmental resource consumption, enabling dynamic adjustments that align supply with actual demand.

4.4 Challenges to TQM Implementation and Countermeasures

Despite the clear benefits of TQM in healthcare, its implementation encounters several challenges that require proactive strategies.

First, resistance among clinical staff represents a primary barrier. Some practitioners may undervalue quality-management initiatives or fear increased workload. To address this, hospitals must strengthen education and advocacy efforts to build buy-in for TQM principles, and introduce incentive structures — such as integrating quality metrics into performance evaluations — to motivate active participation.

Second, difficulties in cross-departmental collaboration can impede progress. Effective quality management spans multiple units and necessitates seamless coordination [16]. Yet, competing departmental priorities and communication gaps often undermine joint efforts. Mitigation strategies include establishing formal communication and coordination mechanisms, clearly delineating roles and responsibilities, and fostering team-building activities that cultivate a spirit of cooperation and shared purpose.

Third, inadequate information-technology infrastructure limits the impact of TQM. Some institutions lack systems capable of real-time data capture and analysis, or face interoperability issues that hinder data sharing. To overcome this, hospitals should increase investments in modern health-IT platforms, prioritize system integration, and promote data-governance standards that facilitate secure, interoperable information exchange.

5 Conclusion

This controlled study demonstrates that TQM substantially improves hospital quality and safety management. Compared with routine practice, TQM implementation led to significant reductions in adverse event rates, enhanced patient satisfaction, shortened lengths of stay, and lower inpatient costs. By systematizing and standardizing care processes, leveraging real-time informatics, and engaging all staff, TQM represents a highly effective model for elevating healthcare outcomes. Future research should assess TQM's applicability in different hospital settings and explore how emerging technologies — such as artificial intelligence and advanced predictive analytics — can further refine quality-management workflows.

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Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

The author contributed solely to the article.

Ethics Approval and Consent to Participate

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Availability of Data and Materials

The data presented in this study are available on request from the corresponding author.

Supplementary Materials

Not applicable.

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