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Root Cause Analysis and Medical Error Prevention: An Integrated Approach Involving Physical Therapy, Medical Informatics, and Healthcare Administration

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Abstract
Background: Medical error is a leading cause of mortality and morbidity globally, representing a critical systemic challenge rather than merely individual failure. The profound human and economic costs demand a shift from a culture of blame to one of proactive safety and continuous improvement.
Aim: This article advocates for an integrated, interdisciplinary approach to medical error prevention, with Root Cause Analysis (RCA) as a cornerstone methodology. It aims to demonstrate how combining the expertise of clinical staff, physical therapists, health informatics professionals, and administrators can effectively identify and mitigate the latent system vulnerabilities that lead to patient harm.
Methods: The article details the structured RCA process as mandated by accrediting bodies like The Joint Commission. This involves forming a multidisciplinary team, meticulous data collection (interviews, records review), and the use of analytical tools like cause-and-effect diagrams to trace adverse events back to their contributory factors across people, processes, and technology.
Results: Effective RCA moves beyond weak recommendations (e.g., re-education) to implement strong, sustainable interventions. These include forcing functions in electronic health records, standardized checklists, barcode medication administration, and workflow redesign. Case illustrations demonstrate how such systemic changes can prevent errors in medication administration, surgery, and diagnostics.
Conclusion: A sustainable safety culture requires a coordinated, interprofessional effort. By leveraging RCA to drive systemic change and empowering all team members—from clinicians to administrators—healthcare organizations can transform incidents of harm into powerful opportunities for learning and prevention.
Keywords: Root Cause Analysis, Medical Error, Patient Safety, Interprofessional Collaboration, Quality Improvement, Sentinel Event, Systems Thinking.

1. Introduction

Medical error remains a pervasive and multifactorial challenge across healthcare systems, commanding sustained attention because of its profound human, ethical, and economic consequences. The 1999 Institute of Medicine (IOM) report catalyzed a global reckoning by asserting that deaths attributable to medical error exceeded those from motor vehicle accidents, breast cancer, or AIDS, reframing error from an individual failure to a systemic quality and safety imperative [1]. Subsequent analyses have underscored the magnitude and preventability of harm: one widely cited estimate suggests that approximately 400,000 hospitalized patients in the United States experience some form of preventable harm annually, while other work has linked more than 200,000 deaths each year to preventable medical errors, placing error among the leading causes of mortality and demanding proportionate policy and clinical responses [2][3][4]. The economic toll is similarly sobering. Depending on the methods and outcomes examined, medical errors have been associated with healthcare costs of around $20 billion per year; in parallel, hospital-acquired infections alone

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have been estimated to drive between $35.7 and $45 billion annually in excess expenditures, illustrating how preventable harm diverts resources from value-generating care and undermines system sustainability [2][3]. Crucially, emerging scholarship has shifted the conversation from blame to understanding the upstream drivers of error. Rather than locating fault solely at the level of the individual clinician, many inquiries identify latent system vulnerabilities—fragmented communication, suboptimal handoffs, poorly designed health information technology, production pressure, and inadequate staffing—as key contributors to unsafe conditions and error propagation [5]. At the same time, differential exposure and susceptibility to harm among patient subgroups have been noted. Patients with multimorbidity, language barriers, or low health literacy, as well as those transitioning across care settings, may be disproportionately vulnerable to diagnostic delays, medication discrepancies, and procedural complications, highlighting the need for equity-focused safety strategies that accommodate clinical complexity and social determinants of health [6]. The ramifications of error extend beyond direct victims; families, caregivers, and the healthcare workforce often experience secondary trauma characterized by moral distress, burnout, impaired performance, depression, and, in extreme cases, suicidal ideation—effects that create feedback loops of risk by eroding vigilance and resilience within care teams [7][8]. Addressing medical error, therefore, is inseparable from safeguarding clinician well-being and fostering a just culture that supports learning and psychological safety.

Against this backdrop, the field has turned to structured improvement methodologies to translate adverse experiences into durable system change. Root cause analysis (RCA) has emerged as a cornerstone technique, offering a rigorous, stepwise process to trace adverse events back to their contributory factors—human, technological, organizational, and environmental—and to design targeted, testable interventions that reduce recurrence [9]. When implemented with fidelity, RCA moves organizations beyond superficial explanations (e.g., "human error") toward actionable redesign, such as standardization of high-risk workflows, resilience engineering for critical processes, human-factors–informed device and interface modifications, and the institution of redundant safety checks proportionate to hazard severity [9]. Importantly, RCA is most effective within a broader quality improvement (QI) framework that includes prospective hazard identification (e.g., failure modes and effects analysis), real-time reporting and near-miss capture, multidisciplinary case review, and continuous measurement of process and outcome indicators. This integrated approach aligns with high-reliability principles—preoccupation with failure, deference to expertise, and a commitment to resilience—that characterize safer industries and are increasingly adopted in healthcare. Moreover, contemporary applications of RCA recognize the necessity of interprofessional participation that spans the full continuum of care. In addition to physicians and nurses, robust analyses engage pharmacists to interrogate medication-use systems, physical therapists to evaluate mobility and fall-prevention pathways, health information professionals to assess clinical decision support and documentation integrity, and administrative professionals to map scheduling, referral, and communication loops that often seed delays and diagnostic errors. Such breadth ensures that corrective actions are not narrowly targeted at a single node of care but rather address the sociotechnical system as a whole, from order entry and specimen handling to bedside therapy and discharge coordination. Embedding patients and families in the analytic process further enriches the understanding of workflow realities and can reveal mismatches between organizational assumptions and lived experience, thereby improving the face validity and uptake of recommended changes [5][6].

Finally, sustained improvement hinges on operationalizing RCA outputs into everyday practice. This requires executive sponsorship to prioritize safety interventions, analytics support to monitor leading and lagging indicators, and frontline empowerment to adapt solutions within local microsystems. Education that normalizes event reporting, teaches human factors and systems thinking, and trains teams in debriefing and communication tools (e.g., SBAR, closed-loop communication) helps convert episodic analyses into a pervasive safety culture. In this article, we examine how RCA can be systematically applied to prevent medical error, survey strategies for embedding continuous QI in clinical operations, and discuss the organizational conditions that enable learning and accountability without blame. By integrating the epidemiology of harm with practical improvement science, the goal is to illuminate a pathway from recognition of the problem's scale to demonstrable reductions in preventable adverse events—improving outcomes for patients, supporting the workforce, and reducing the economic burden borne by healthcare systems [1][2][3][4][5][6][7][8][9].

Function

Medical error, defined by the Institute of Medicine as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim," remains a systems-level phenomenon that can arise anywhere along the continuum of care—from triage and diagnostic assessment to procedural intervention, handoffs, discharge, and post–acute follow-up [1]. Distinguishing medical error from malpractice is essential for fair adjudication and effective quality improvement. Whereas malpractice hinges on legal standards of negligence and breach of duty, medical error encompasses unintended failures of planning or execution that may or may not meet legal thresholds but still signal vulnerabilities in clinical processes, human–technology interfaces, and organizational design. This distinction matters because a narrow legal lens risks locating fault in individual performance alone, while a safety lens foregrounds latent conditions such as communication breakdowns, poorly designed order sets, alarm fatigue, device usability flaws, or staffing and workload pressures that predispose frontline teams to slip, lapse, or mistake. Notably, errors can occur without immediate patient harm; yet even near misses represent vital learning opportunities. Rigorous evaluation of these events—harmful or not—enables proactive redesign before risk crystallizes into injury, aligning everyday practice with high-reliability principles and strengthening a culture of safety that prizes curiosity over blame [10][11]. Functionally, a mature safety program treats the detection, disclosure, and analysis of error as integral clinical work. It builds redundant defenses around high-hazard processes; it trains teams in standardized communication (e.g., closed-loop readbacks and escalation triggers); and it integrates electronic decision support that is sensitive to context while minimizing alert fatigue. At the same time, it supports clinicians and staff who are involved in adverse events—the so-called “second victims”—recognizing that unaddressed moral distress and burnout can perpetuate risk. In this way, the “function” of error management is not episodic remediation after a crisis but continuous, data-driven improvement that couples frontline insight with leadership accountability. Because error mechanisms are multifactorial, the most effective countermeasures are multifaceted: they combine education and simulation with human-factors engineering, policy standardization with local adaptability, and retrospective learning from events with prospective hazard analysis. Near-miss capture, in particular, is a critical functional pillar; these events share upstream causes with actual harm events and thus supply a higher-frequency signal for system tuning before injury occurs [10][11]. A further functional imperative is equitable safety. Populations with language barriers, low health literacy, multimorbidity, or limited access to follow-up may be disproportionately exposed to diagnostic delays, medication discrepancies, and post-discharge failures. A learning health system explicitly measures such disparities and codesigns countermeasures—targeted teach-back, multilingual materials, culturally responsive care navigation—so that safety improvements do not inadvertently widen gaps. In addition, frontline teams must be empowered to halt unsafe processes without fear of reprisal, and management must respond to signals with timely, visible action. In these ways, the function of a modern safety ecosystem is to transform individual errors into organizational knowledge, thereby reducing recurrence and improving outcomes at scale [10][11].

Sentinel Events and Root Cause Analysis

Within this safety architecture, sentinel events occupy a special category of urgent concern. The Joint Commission defines a sentinel event as an unexpected occurrence involving death, serious physical or psychological injury, or the risk thereof—explicitly including process variations that, if repeated, would have a significant chance of causing serious adverse outcomes [12]. By definition, these events demand immediate investigation, leadership engagement, and corrective action because they signal that multiple defenses failed simultaneously. Importantly, sentinel events are independent of the patient’s underlying disease trajectory; they are attributable to medical intervention or technique, which is why they are reportable to the accrediting body when they involve unexpected mortality, significant permanent harm, or severe, temporary harm requiring life-sustaining intervention [12][13]. The obligation to report is coupled with the obligation to learn: organizations must not only notify but also demonstrate a credible causal analysis and the implementation and monitoring of effective countermeasures. In practice, clinical teams must also parse clinical causality. For example, if a patient develops anaphylaxis after a medication, the investigation must determine whether the reaction was idiosyncratic or whether a failure to screen, document, reconcile, or heed allergy information contributed. This discriminating review is often challenging because contemporaneous documentation may be incomplete, memories degrade quickly after crises, and multiple small contributors can interact in nonlinear ways to produce catastrophic harm. Yet it is precisely this complexity that necessitates a disciplined analytic method [12][13]. Root cause analysis (RCA) provides that discipline. Mandated by the Joint Commission for qualifying sentinel events, RCA is a structured, iterative process for identifying proximate and latent factors that set the conditions for error, with the explicit aim of redesigning systems rather than assigning personal blame [13]. A robust RCA begins with immediate containment and disclosure to ensure ongoing patient safety and transparent communication. The analytic team is multidisciplinary and includes individuals with process expertise but not direct involvement in the event to minimize hindsight bias. Data collection triangulates sources: medical records, device logs, medication administration records, interviews with clinicians and patients or families, and environmental scans of workspace layout and equipment. Chronologies and time–person–place maps reconstruct the event pathway from antecedents to outcome.

Analytic tools then help the team move beyond the surface narrative. Five-Whys questioning drills down from observed failure to contributing conditions; cause-and-effect (Ishikawa) diagrams array contributing factors across domains such as people, process, equipment, environment, and management; and the Swiss-cheese model visualizes how layered defenses—policies, order sets, bar-code medication administration, independent double checks—develop holes that align under specific pressures. The goal is not to find the single root but to identify a cluster of actionable causes at different system levels: for instance, ambiguous order sentences in the electronic health record that enable look-alike/sound-alike selection; an allergy field that does not hard-stop high-risk orders; a staffing pattern that pairs two novices on a high-acuity unit; or a handoff protocol that omits "watch items" such as pending critical results. Throughout, the team must separate contributory factors from mere correlates and test hypotheses against the data to avoid premature closure [13]. Crucially, RCA must culminate in corrective actions that are "strong" rather than merely exhortative. Education, memos, and policy reminders are weak controls because they depend on constant human vigilance in noisy environments. Stronger actions include forcing functions in order entry that block unsafe dosing, standardized kits or procedural checklists with read-do confirmation, engineering controls such as non-interchangeable connectors, and redesign of workspace to reduce interruptions at critical steps. Action plans specify responsible owners, timelines, required resources, process and outcome metrics, and verification strategies. For example, after a wrong-dose chemotherapy incident, a strong plan might include computerized provider order entry hard stops for dose-per-m^2 outliers, mandatory pharmacist–oncologist independent double checks for first-cycle regimens, smart-pump libraries with soft and hard limits, and a no-interruption zone during compounding and bedside programming. The plan would then define audit frequency, compliance thresholds, and statistical process control methods to verify sustained effect.

Monitoring and feedback close the loop. Organizations track leading indicators (e.g., near-miss reports, adherence to independent double checks, allergy documentation completeness) and lagging indicators (e.g., dosing errors causing harm), stratified by unit and patient group to detect inequities. Leadership reviews progress at regular intervals, removes barriers, and adjusts resources. Event debriefings and simulation reinforce new practices. Communication back to frontline teams is essential to maintain reporting engagement; when staff see that reports lead to tangible improvements rather than punishment, psychological safety grows and surveillance net widens. Parallel attention to the well-being of involved clinicians—peer support, just-culture interviews that separate human error, at-risk behavior, and reckless behavior—prevents secondary harm and sustains capacity for vigilance. Finally, RCA's value expands when embedded in a broader safety ecosystem that includes prospective methods such as failure modes and effects analysis for new technologies or workflows, trigger tools to detect occult harm, and real-time clinical surveillance for deterioration. In such an ecosystem, sentinel events become rare outliers, and most hazards are intercepted as near misses or corrected proactively. This integrated approach honors the spirit of the Joint Commission's mandate: not merely to analyze after harm, but to build learning systems that continuously anticipate, detect, and defuse risk across the full arc of care [12][13][10][11].

Applying Root Cause Analysis

For accreditation, the Joint Commission requires every healthcare organization to maintain a robust, systematic method for analyzing sentinel events; root cause analysis (RCA) is the most widely adopted mechanism to meet this mandate [14]. Conceptually, RCA is more than a retrospective postmortem—it is a structured learning process that interrogates *why* an adverse event occurred, iteratively asking "why" until the inquiry reaches remediable system vulnerabilities rather than stopping at proximate human errors. The emphasis is explicitly on lapses in system-level processes and organizational conditions, not on individual blame. Practically, the process begins as soon as a sentinel event is recognized: the accountable leaders commission an RCA, appoint a multidisciplinary team, establish communication cadences with senior leadership, and map internal milestones so that the investigation satisfies both patient-safety imperatives and Joint Commission timelines [14]. Because the analytical window is finite—failure to complete an RCA within 45 days may trigger a public accreditation watch and, with repeat lapses, an onsite review jeopardizing accreditation—the institution must mobilize quickly while ensuring analytic rigor [15]. The formative step in any RCA is to constitute an interprofessional team with the right mixture of domain knowledge and independence. The team typically includes frontline clinicians from the involved microsystems, human-factors and quality-improvement specialists, pharmacy or device experts where relevant, and representatives from risk management and patient relations to support disclosure and communication. Early actions are bifurcated: first, immediate containment and interim risk-reduction measures to prevent a repeat event during the investigation; second, problem definition and scoping so that the analysis remains focused on preventable causal pathways rather than diffuse speculation [14]. Data collection proceeds in parallel. The team triangulates the medical record, order sets, device and pump logs, laboratory and imaging timestamps, staffing rosters, and environmental observations with nonpunitive, confidential interviews of involved staff and, when appropriate, patients and families. This record is organized into a high-resolution process map and a time–person–place chronology that reconstructs the event trajectory from antecedents to outcome, making visible where barriers failed and how latent conditions aligned to permit harm [14][13].

As the evidentiary corpus takes shape, the team turns to analytic frameworks that discipline causal inference. The "Swiss Cheese Model" is a frequently used lens, positing that injuries occur when holes in multiple layers of defense—unsafe acts, preconditions for unsafe acts, supervisory factors, and organizational influences—line up to allow a hazard to reach the patient [16]. Applying this model, the team identifies breakdowns across the four strata: for example, an unsafe act (a high-risk medication programmed at the wrong concentration); preconditions (interruptions and alarm noise at the medication station); supervisory factors (rostering two novices together on a high-acuity unit); and organizational influences (an electronic order set that permits look-alike/sound-alike selections without hard stops). The Joint Commission's 24-question framework complements this analysis by ensuring breadth and completeness; it prompts systematic consideration of process design, human factors, equipment performance, environment, uncontrollable externalities, organizational policies, staffing levels and qualifications, contingency planning, performance expectations, communication pathways, and the role of technology [13]. Because communication breakdowns frequently seed adverse events, the framework explicitly probes intra- and inter-team communication, message clarity and timeliness, and the adequacy of formal channels (e.g., handoffs, consult requests) and informal workarounds that may have supplanted them [13]. In parallel, the environment is scrutinized for lighting, noise, layout, and workflow interference; staffing analyses verify whether numbers, skills, and supervision were matched to acuity and whether credentialing and competencies were current for the assigned duties [17]. A distinctive strength of RCA is its capacity to move from narrative to mechanism to remedy. Once contributory factors are confirmed, the team prioritizes corrective actions that are proportionate to hazard severity and *strong* in their expected effect size. Education and policy reminders—while sometimes necessary—are weak controls because they rely on unwavering human vigilance; stronger remedies include forcing functions in computerized order entry, standardized kits and checklists with read-do verification, redesigned interfaces that eliminate confusing defaults, engineered incompatibilities that prevent misconnections, and predictable staffing models that cap interruptions during safety-critical tasks [13]. Each action is paired with clear ownership, resources, and time-bound milestones, and with measures at both the process level (e.g., compliance with independent double checks) and outcome level (e.g., reduction in near-miss reports of the same type). During the RCA, the team is expected to implement immediate safeguards where feasible—temporary hard stops, shadow double checks, or cohorting of high-risk workflows—so that learning translates into near-term risk reduction rather than deferred promises [14].

The scope of sentinel events subject to the Joint Commission's purview illustrates why rigor and speed are imperative. Reportable categories include, among others, patient suicide within 72 hours of discharge from any care setting (including the emergency department), unexpected serious events in full-term infants, infant discharge to the wrong family, abduction, harmful elopement, hemolytic transfusion reactions, rape or assault or homicide on healthcare premises, wrong-patient/site/procedure surgeries, unintended retention of a foreign object postoperatively, severe neonatal hyperbilirubinemia, prolonged fluoroscopy to the wrong body region, fire or unanticipated smoke/heat during care, intrapartum maternal death, and severe maternal morbidity [17]. These events are, by definition, unrelated to the patient's underlying illness trajectory and instead attributable to failures in medical intervention or technique; therefore, they demand immediate investigation and targeted remediation to prevent recurrence [13][17]. In ambiguous scenarios—for example, anaphylaxis after drug administration—the RCA must distinguish idiosyncratic reactions from preventable failures to screen, document, reconcile, or heed allergy information, a determination that often hinges on the completeness of records and the fidelity of safety checks [13]. Producing an RCA that meets Joint Commission standards requires more than assembling facts. The final report must document leadership participation and stakeholder engagement, present a thorough and internally consistent analysis without contradictions or unanswered questions, and explicitly reference relevant literature or external advisories where applicable, situating local findings within broader evidence and safety alerts [17][13]. It must also articulate how the organization will verify the effectiveness of corrective actions—what measures will be used, at what frequency they will be audited, and how results will be fed back to frontline teams and governance bodies. Because the Joint Commission may place an organization on accreditation watch for missed timelines or inadequate analyses, the reporting and governance pathway must be clear from the outset: senior leadership should receive interim briefings; legal and patient relations teams should align on disclosure and apology; and quality committees should preschedule follow-ups to review implementation progress and outcome trends within and beyond the 45-day window [15][14].

Sustaining RCA's value requires embedding it within a broader learning system. Near-miss reporting, trigger tools, and real-time surveillance expand the signal from rare catastrophic events to more frequent precursors, allowing faster cycle times for improvement. Education in just culture and human factors equips staff to report without fear and to design with users in mind. Finally, equity must be explicit:

the same 24-question lens should be applied with stratification by language, race/ethnicity, and socioeconomic status to ensure that corrective actions do not inadvertently widen disparities in safety or access. When organizations treat RCA not as a compliance exercise but as the nucleus of a continuous improvement engine—interfacing with leadership, analytics, frontline expertise, and patient voices—they convert sentinel events into catalysts for durable redesign, thereby reducing the likelihood of recurrence and meeting both the spirit and letter of Joint Commission expectations [13][14][16][17][15].

Case Illustrations with Root Cause Analysis Interventions — 500-word summary

These six cases highlight diverse error modes across obstetrics, ambulatory care, and ophthalmic surgery, and show how root cause analysis (RCA) converts near misses and adverse events into system redesign. In **Case 1**, a primigravida with severe preeclampsia nearly received an incorrect magnesium sulfate regimen during an urgent, high-stress situation. Contributing factors included a complex IV/IM protocol, a faded preparation chart, verbal orders, and time pressure. The RCA reclassified magnesium sulfate as a high-alert drug per Institute for Safe Medication Practices guidance, replaced on-unit mixing with pharmacy-premixed bolus solutions, preserved two-nurse independent verification (dose, pump settings, drug, concentration), and mandated written/electronic ordering via CPOE with read-back for any unavoidable verbal orders. The emphasis was on strong controls that do not rely solely on memory. **Case 2** involved two obstetric inpatients with look-alike names and birthdates; a nurse—new to the ward amid high workload—administered insulin to the wrong patient despite using two identifiers. The event exposed vulnerabilities in handoffs, language access, and identity verification. RCA actions standardized shift handoffs (structured format and training), required hospital interpreters for non-English-speaking patients, added mandatory barcode armband scans before every medication, and visually flagged charts/rooms when patients have similar names/dates. A just-culture stance avoided individual blame and focused on interprofessional communication reliability.

In **Case 3**, a missing sponge count during an emergent cesarean prolonged operative time. The analysis found inconsistent, single-person counts. Corrective measures mandated the WHO Surgical Safety Checklist for all procedures, standardized audible/visible counts by both scrub and circulating nurses, and required counts before incision and before closure, independent of urgency. The goal was to eliminate variation and reduce reliance on vigilance alone. **Case 4** described a near wrong-eye sequence during bilateral LASIK when iris recognition repeatedly failed and the table was positioned for the opposite eye. A vigilant circulating nurse hit emergency stop. RCA recognized bilateral procedures as high risk for laterality errors, especially when treatment differs by eye. Countermeasures instituted triple verification of refractive targets by optometrist, technician, and surgeon before and after laser programming; when available, iris recognition served as an engineered defense, and when unavailable, teams adopted read-do checks with explicit eye confirmation. The intervention also reinforced nurse/technician authority to halt procedures. **Case 5** showed ambulatory dosing misinformation: a typographical error in a visit summary doubled a child's cetirizine dose; subsequent callback triage compounded the problem with reassurance lacking document review. The RCA implemented a dual verbal-and-written verification step for any transcribed orders or over-the-counter instructions, required clinicians/staff to read doses directly from the visit summary to caregivers and confirm concordance with chart notes, and mandated document review before any telephonic advice. **Case 6** featured pre-procedure medication mix-up in a high-throughput laser center: a patient scheduled for YAG iridotomy received a mydriatic instead of pilocarpine, detected at the laser when the pupil was dilated. The RCA segregated patient flow and physical spaces for YAG iridotomy versus capsulotomy, fixed storage of drops to procedure-specific zones, and added barcode verification at each instillation to prevent look-alike/sound-alike drug errors under workload pressure. Across cases, recurrent RCA themes emerged: replace memory-dependent steps with forcing functions and standardization; strengthen identification with barcoding; institutionalize structured handoffs and language services; adopt team-empowering stop rules; and use checklists and engineered barriers (CPOE, smart verification) to intercept error. Collectively, these changes embody systems thinking—addressing process, environment, technology, staffing, and communication—to reduce recurrence and enhance safety culture.

Issues of Concern

The scale and persistence of preventable harm make medical errors a central concern for clinicians, administrators, and policymakers alike. The Institute of Medicine (IOM) identified medical errors as a leading cause of death and injury, a conclusion echoed in the World Health Organization's 2019 Patient Safety Factsheet, which places adverse events from unsafe care among the top ten causes of death and disability globally [1]. In the United States, estimates suggest that 44,000 to 98,000 hospital deaths annually are attributable to preventable adverse events—numbers that exceed deaths from motor vehicle collisions—while the broader economic burden from healthcare costs, disability, and lost productivity is projected at $37.6 to $50 billion each year [1]. These figures are more than statistics: they represent profound human consequences borne by patients, families, and the healthcare workforce. Because harms stem largely from modifiable systems failures, the disciplined use of root cause analysis (RCA) is indispensable for identifying latent hazards and implementing corrective measures that prevent recurrence at scale [1]. A central concern is conceptual clarity regarding the types and mechanisms of error so that improvement strategies can be appropriately targeted. Errors are not confined to individual miscalculations or lapses in communication; some are tightly coupled to inherent risks of clinical situations, such as inpatient falls or healthcare-associated infections, where system design and vigilance determine event rates [3][18]. Surgical, diagnostic, and medication errors, equipment failures, hospital-acquired infections, falls, and communication breakdowns recur across settings, each with distinct epidemiology and preventable pathways that call for tailored countermeasures [3][18]. Because these domains intersect—consider a postoperative patient with a device, high-risk drugs, and language barriers—safety programs must synthesize interventions rather than tackle hazards in isolation [3][18].

Surgical errors exemplify high-severity events with catastrophic potential. Intraoperative failures are implicated in roughly three quarters of malpractice cases involving surgeons, and wrong-site, wrong-patient, or wrong-procedure events should never occur in a functioning safety system [19]. RCA investigations repeatedly surface contributory factors such as time pressure, distractions, fatigue, miscommunication during handoffs, shifting or inadequate staffing, and organizational lapses, including specimen labeling and documentation errors, as well as cognitive pitfalls at the point of decision-making [19]. Effective remedies therefore pair engineered barriers—time-outs, site-marking, standardized instrument and sponge counts, checklists—with human-factors interventions that protect attention, stabilize teams, and structure communication. When strong controls are reliably implemented, they narrow the margin for error even when clinical urgency is high, an imperative given the disproportionate harm associated with operative mistakes [19]. Diagnostic error presents a different but equally consequential concern. The National Academy of Medicine defines diagnostic error as failure to establish an accurate and timely explanation of a patient's health problems or to communicate that explanation to the patient, thereby encompassing delays as well as missed and miscommunicated diagnoses [20]. The Joint Commission estimates that diagnostic errors injure or kill 40,000 to 80,000 patients annually, with risk accentuated in primary care solo practices where heavy workloads, compressed visit lengths, and limited collegial consultation hinder cognitive checks and timely follow-up [21]. Malignancies, surgical complications, and neurologic, cardiac, and urologic conditions are among the most frequently misdiagnosed categories, often because of knowledge gaps that undermine bedside assessment and clinical reasoning [22][23][24]. RCA often traces such events to cognitive contributors—premature closure, failure to consider alternatives, anchoring bias—compounded by system failures in test tracking, result communication, and follow-up planning [25]. Addressing diagnostic error thus requires a dual approach: strengthening clinicians' diagnostic calibration through feedback and education while instituting system solutions like reliable test-result management, safety nets for high-risk presentations, and structured follow-up protocols that reduce reliance on memory under time pressure [11][21].

Medication errors remain the most common and preventable cause of patient injury because the medication-use process spans prescribing, transcribing, dispensing, dosing, and administration across multiple settings and handoffs [26]. In acute hospitals, approximately 6.5 adverse drug events occur per 100 admissions, and errors at transitions—before admission or after discharge—are especially easy to miss [26]. RCA frequently reveals look-alike/sound-alike drug confusions, dose/calculation mistakes, allergy or interaction oversight, and administration issues linked to interruptions and workload. High-leverage solutions include computerized provider order entry with clinical decision support, unit-dose dispensing, barcode medication administration, independent double checks for high-alert drugs, and pharmacist-led reconciliation at admission and discharge, complemented by patient education that verifies understanding of indications and dosing using teach-back [26]. Equipment-related errors illustrate the sociotechnical nature of modern care. Design flaws, user error, manufacturer variation, inadequate maintenance, and hardware malfunction all contribute to risk, with implanted devices such as pacemakers and stimulators adding complexity when failures occur [27][28]. Tube and catheter misconnections—feeding formula into the venous system or intravenous infusions routed through the wrong line—remain particularly dangerous, often stemming from incompatible connectors and confusing layouts [27][28]. RCA supports adoption of systems-level countermeasures such as non-interchangeable, procedure-specific connectors; standardized line labeling; smart pumps with dose-error reduction systems; and rigorous preventive maintenance schedules, alongside simulation-based training that cultivates device literacy and situational awareness under realistic workload conditions [27][28].

Hospital-acquired infections (HAIs) represent systemic failures with large population impact; up to one in twenty hospitalized patients may acquire an infection, adding substantial morbidity, mortality, and an estimated $35 billion in annual costs in the United States alone [29]. RCA of HAI clusters routinely implicates lapses in basic hand hygiene, breaks in sterile technique, and variation in catheter insertion and maintenance practices, translating to targeted bundles for catheter-associated urinary tract infections, central line–associated bloodstream infections, ventilator-associated pneumonia, and surgical site infection prevention [29]. Sustaining gains requires practical enablers—ready access to supplies, workflow-aligned checklists, empowered nurse champions, and transparent unit-level feedback—because the interventions are simple but execution must be flawless at scale [29]. Falls are another cross-cutting concern. Among people older than 65, more than one third will fall each year, and one third of these events cause injury, with inpatient risks amplified by postoperative status, medications, hypoglycemia, delirium, advanced age, mobility impairment, and staffing constraints [30][31]. RCA commonly identifies modifiable contributors such as inconsistent risk assessment, inadequate assistive devices or supervision, environmental hazards, and sedative polypharmacy. In response, multifactorial fall-prevention programs combine standardized risk stratification, medication review and deprescribing, strength and balance training, toileting schedules, visual and auditory aids, environmental modifications, and purposeful rounding, supported by data feedback to maintain adherence in busy units [31]. Communication failures inhabit nearly every serious safety event. Effective interprofessional and patient–clinician communication is foundational, yet it is routinely undermined by disruptive behaviors, noise and interruptions, cultural and language differences, hierarchical dynamics, personality clashes, and socioeconomic and literacy barriers [32]. Written communication introduces its own hazards: nonstandard abbreviations, illegible handwriting, unquestioned ambiguous orders, and specimen mislabeling persist despite electronic systems [11]. RCA-driven improvements emphasize standardized handoffs, closed-loop read-backs, escalation protocols with clear triggers, professional interpreter services for limited English proficiency, and simplified, pictogram-supported patient instructions that align with health literacy levels. Cultivating a just culture that rewards speaking up and psychological safety is essential so that nurses, pharmacists, and technicians feel authorized to halt a process when they detect risk, a theme that recurs across high-reliability organizations [11][32].

Importantly, issues of concern are not limited to the immediate clinical microsystem. Workload, staffing ratios, and scheduling models shape error probability; production pressures and frequent interruptions during high-risk tasks correlate with slips and lapses, while rotating staff without adequate orientation elevates vulnerability in specialized units [19][31]. Information technology can mitigate or magnify hazards: decision support curbs dosing errors, yet poorly designed interfaces and excess alerts induce fatigue, workarounds, and new error pathways that only become evident through vigilant monitoring and event analysis [26][27]. Equity is also a safety issue. Patients with limited English proficiency or low health literacy bear disproportionate risks of communication-related errors, delayed diagnoses, and post-discharge failures, underscoring the need to embed language access and culturally responsive education into standard workflows rather than treating them as optional add-ons [21][32]. Finally, transparency and learning require robust reporting systems that capture near misses and unsafe conditions in addition to harm events; without this broader signal, organizations will chase headlines while missing upstream opportunities to defuse risks before patients are injured [3][18]. Given this landscape, RCA serves as a unifying methodology to translate harms and hazards into durable change. By insisting on a system-focused lens, interrogating human factors and environmental conditions, and prioritizing strong, engineered controls over exhortations to "be careful," RCA helps align local practice with evidence-based safety science [3][18][19]. Its impact depends on timeliness, leadership engagement, interdisciplinary participation, and measurable follow-through so that recommendations convert into standardized processes, reliable tools, and sustained outcome improvement. In sum, the principal issues of concern—burden of harm, diversity of error types, sociotechnical complexity, communication failures, workload and equity pressures—are precisely those that RCA is designed to address. When organizations deploy RCA consistently and couple it with continuous monitoring and a just culture, they move beyond episodic fixes toward a learning system capable of preventing recurrence and narrowing the persistent gap between what we know improves safety and what patients actually experience at the bedside [29][30][31][32].

Clinical Significance

Root cause analysis (RCA) has become a cornerstone of modern patient-safety practice because it translates adverse outcomes into actionable systems learning rather than retrospective blame. By design, RCA compels organizations to reconstruct the clinical, human-factors, and organizational conditions surrounding harm events, trace contributory pathways, and implement corrective actions whose strength is proportionate to the hazard. This approach is especially consequential given the scope of preventable harm highlighted by the Institute of Medicine and subsequent analyses, which identify medical errors as a leading cause of death and injury and a major driver of excess cost, disability, and lost productivity [1]. The clinical salience is not abstract: RCA focuses institutional attention on sentinel events most closely linked to mortality and serious morbidity and repeatedly surfaced in Joint Commission data, including surgical errors, diagnostic errors, patient suicide, medication errors, equipment errors, hospital-acquired infections, patient falls, and communication errors [13]. Because each of these categories represents a distinct constellation of failure modes, the practical value of RCA lies in its disciplined capacity to differentiate proximal missteps from latent system defects and to hardwire safer processes that reduce recurrence. In surgical care, the stakes of reliability are self-evident: wrong-site surgery, retained items, and perioperative mismanagement are rare but catastrophic failures that undermine trust and cause irreversible harm. RCA findings across organizations converge on similar contributory factors—time pressure, interruptions, ambiguous or poorly designed order sets, incomplete consent reconciliation, and variability in counting practices—suggesting that sustainable improvement requires standardization anchored by checklists and engineered barriers. The routine use of structured time-outs that require active participation by the entire team, explicit confirmation of patient identity, procedure, site and side, reconciliation with the consent form, and visible skin marking of the operative site has been associated with reductions in wrong-site events; when multiple procedures or teams are involved, separate time-outs eliminate laterality confusion and cognitive overload [33]. RCA often adds local specificity, such as adopting radio-frequency–detectable sponges, enforcing audible and visual two-person counts before incision and before closure, and mandating intraoperative radiography when counts are discordant—interventions that directly mitigate the latent conditions identified during analysis [3][13][34][35].

Diagnostic safety presents a different profile. Errors in diagnosis frequently arise at the intersection of cognitive bias and system design—premature closure on an early hypothesis, failure to consider a broad differential under time pressure, and fragile follow-up systems that allow test results to fragment across transitions. The National Academy of Medicine's definition underscores that delays and communication failures are as important as inaccuracies, offering a wider aperture for intervention [20]. RCA-driven countermeasures increasingly blend cognitive support with workflow redesign: electronic trigger tools that mine electronic health records for "signals" of potential misses, such as unplanned returns to care or abnormal results without follow-up; checklists and algorithms that serve as cognitive forcing functions for commonly misdiagnosed conditions; and decision-support prompts embedded at the point of ordering and documentation [11][36]. Evidence summarized since 2015 suggests that trigger tools can reduce missed opportunities by prompting timely clinician review, while expanded access to specialty input, simulation-based training, and structured case conferences normalize second opinions and reflective practice in ambiguous presentations [24][36][37]. Because ingrained habits and overconfidence can attenuate the effect of such tools, RCA recommendations often include teaching "pause and reflect" techniques and creating protected time for diagnostic debriefs, thereby embedding metacognition into daily work [25]. Preventing patient suicide demands a comprehensive safety net that spans environment, staffing, screening, and communication. Sentinel event reviews repeatedly identify modifiable opportunities: reliable suicide risk assessment at intake and at clinically meaningful junctures, elimination of environmental hazards, continuous observation protocols calibrated to risk, and closed-loop communication among all treating clinicians. RCA therefore typically catalyzes standard work for contraband checks, escalation thresholds, staffing contingencies on high-acuity units, and documentation templates that make risk formulation and mitigation plans explicit and trackable in the record [13]. The practical aim is to replace ad hoc vigilance with predictable processes that cannot be skipped during periods of crowding or turnover.

Medication safety remains the most common terrain for preventable injury precisely because it spans multiple steps—prescribing, transcribing, dispensing, administration, and monitoring—across settings and handoffs. RCA nearly always uncovers a mix of look-alike/sound-alike confusions, dosing and calculation errors, incomplete allergy or interaction checks, and administration lapses linked to interruptions and workload. High-leverage responses emphasize technology facilitated by human-factors design: computerized provider order entry with decision support and standardized order sets; barcode medication administration that couples patient identity with the right drug, dose, route, and time; independent double checks for high-alert medications; and pharmacist-led reconciliation at admission and discharge [26]. Complementary work design includes standard concentrations for vasoactive agents, immediate syringe labeling at preparation, segregation of look-alike products, removal of high-risk drugs from floor stock, and capitalized "tall-man" lettering on labels to distinguish similar names [11][3]. RCA frequently recommends automatic dispensing cabinets that free pharmacists for reconciliation and education, while simultaneously warning against workarounds that bypass barcode safeguards, which reintroduce risk at the bedside [26][38]. Equipment-related errors illustrate the sociotechnical nature of harm: user interface complexity, inadequate training, lax maintenance, and manufacturer variation can conspire to produce rare but severe events. RCA commonly drives policies that require unique, non-interchangeable connectors for anesthesia, enteral feeding, and intravenous lines to prevent misconnections; line-tracing to the source before connecting or starting infusions; explicit high-risk catheter labeling; and preventive maintenance schedules tied to risk categories [27][28][40]. Because devices can lull teams into false security, education emphasizes "automation vigilance," scenario-based simulation for failure modes, and rapid reporting of device anomalies into a centralized monitoring system that supports both local fixes and enterprise-wide hazard advisories [39].

Hospital-acquired infections (HAIs) remain an emblematic systems-failure domain where simple behaviors, executed flawlessly and consistently, produce outsized gains. RCA of clusters and trends typically points to gaps in hand hygiene, sterile technique, and catheter insertion and maintenance practices. The ensuing countermeasures are now familiar and evidence-based: hand hygiene campaigns with real-time feedback and champions; insertion bundles for central venous and urinary catheters that standardize barrier precautions, chlorhexidine skin preparation, and site care; and protocols that minimize catheter days and trigger automatic removal when indications lapse [41][3]. Pharmacy-driven antimicrobial stewardship programs reduce selective pressure and downstream infections, while wound-care team rounding, nursing education, and evidence-based dressings—including chlorhexidine-impregnated options where appropriate—lower the risk of pressure injuries and surgical site infections [42][43][3]. RCA often adds operational glue—ensuring supply availability at point of care, simplifying documentation, and public display of unit-level performance—to sustain adherence beyond initial enthusiasm [41]. Falls are both ubiquitous and multifactorial. RCA consistently finds a mix of intrinsic risks—advanced age, orthostasis, hypoglycemia, delirium, postsurgical sedation—and extrinsic contributors such as environmental hazards, inadequate supervision, and staffing patterns that concentrate novices on high-acuity units. In response, high-reliability programs move beyond signage to comprehensive bundles: standardized risk assessment tools like the Morse Fall Scale; medication reviews with deprescribing of deliriogenic and sedating agents; mobility and balance training with rehabilitation professionals; purposeful rounding that anticipates toileting and pain needs; nutrition support; and patient-specific safety companions for the highest-risk individuals [31][3]. Home-safety counseling at discharge, with attention to lighting, stairs, and assistive devices, extends prevention beyond the ward and addresses the transition period when risk remains elevated [13].

Communication reliability binds all other domains. Across sentinel events, RCA exposes recurring breakdowns in interprofessional dialogue and patient-facing communication, amplified by language barriers, hierarchy, workload, and health literacy constraints. The Joint Commission's National Patient Safety Goals crystallize key behaviors, including mandatory "read-back" of critical values and verbal or telephone orders, with explicit acknowledgment by the ordering practitioner, and consistent use of at least two patient identifiers when labeling specimens, administering medications, or transferring patients [11]. Organizations that act on RCA findings hardwire structured handoffs using standardized mnemonics such as SBAR to ensure that situation, background, assessment, and recommendation are communicated clearly and concisely, ideally in real time with opportunities for questions to resolve ambiguities [46][47][48]. Written communication is de-risked by banning nonstandard abbreviations, enforcing legible electronic documentation, and instituting double checks for specimen labels and medication instructions. Because age-related hearing, vision, and cognitive changes raise miscommunication risk, teams tailor education and confirmation methods—teach-back, pictogram-supported instructions—to older adults and caregivers, and they extend the same tailored approaches to infants and children whose caregivers must intermediate all decisions [11]. Just as crucial, hospitals elevate professional interpreter services from optional to obligatory when language discordance is present, and they embed clinician–family bedside rounds that enable bidirectional communication; such practices have been associated with reduced harmful errors and improved family experience [44]. The common thread through these domains is the preventive logic that animates RCA. By identifying deficiencies, failures, and risk factors with rigor, organizations can design corrective measures that specifically neutralize the mechanisms of harm rather than relying on exhortations to "be careful." Importantly, RCA's clinical significance extends beyond the initial report: corrective actions must have owners, timelines, and verification plans; monitoring must pair process measures—e.g., hand hygiene adherence, barcode scan compliance—with patient outcomes—e.g., central line–associated bloodstream infection rates, fall-related injuries—to validate effect size and detect regression. Leadership sponsorship, front-line engagement, and transparent feedback loops convert recommendations into sustained practice change. When clinicians participate actively in RCA, they surface the tacit knowledge necessary to redesign workflows; when organizations respond visibly and consistently, a just culture takes root, reporting rises, and the surveillance net expands to capture near misses before they mature into injury. In this way, RCA operationalizes the safety mandate embedded in the sentinel event framework, turning painful lessons into durable improvements across surgical care, diagnosis, suicide prevention, medication-use systems, device safety, infection prevention, fall reduction, and communication reliability [47][48].

Enhancing Healthcare Team Outcomes

Medical error prevention is not solely the responsibility of physicians and nurses—it is a multidisciplinary commitment that requires active collaboration among all healthcare professionals. Within this framework, health information specialists, physical therapists, and medical secretaries play vital yet sometimes underrecognized roles in ensuring patient safety, improving care continuity, and strengthening organizational learning through root cause analysis (RCA). Each discipline contributes unique expertise that directly supports clinical decision-making, communication, and error prevention across the healthcare continuum.

Health Information Professionals:

Health information professionals serve as the backbone of clinical documentation, ensuring that every medical record accurately reflects the patient's history, diagnostics, and treatment course. In the context of RCA, they are indispensable for data retrieval, verification, and analysis. Accurate health information enables the RCA team to reconstruct events leading to an adverse incident, track medication orders, and review care timelines. Misfiled or incomplete data can obscure root causes, resulting in ineffective corrective measures. Health information management (HIM) specialists also safeguard patient data through compliance with HIPAA and institutional privacy regulations. They implement standardized coding and terminologies, such as ICD-10 and SNOMED CT, which are critical for data consistency across departments. These standardized systems allow RCA investigators to compare cases, detect error trends, and evaluate performance indicators systemically rather than anecdotally. Furthermore, the integration of electronic health records (EHRs) and computerized provider order entry (CPOE) systems has transformed how clinicians communicate and document care. Health information specialists ensure these digital tools are optimized for usability and accuracy—creating alerts for potential medication interactions, preventing duplicate testing, and flagging abnormal results that require physician attention. When errors occur due to data-entry inaccuracies or system malfunctions, HIM experts provide technical and procedural insights that help RCA teams redesign workflows to enhance interoperability and clinical safety. The education role of health information professionals is equally significant. By training clinical staff on best documentation practices, avoiding ambiguous abbreviations, and ensuring real-time data entry, they foster a culture of accountability and precision. Their analytical acumen also contributes to quality improvement dashboards that track sentinel events and measure the efficacy of implemented corrective actions over time.

Physical Therapists:

Physical therapists (PTs) are critical front-line contributors to patient safety, particularly in preventing falls, postoperative complications, and musculoskeletal injuries—some of the most common sentinel events identified by the Joint Commission. Their role extends beyond rehabilitation; PTs perform comprehensive mobility and balance assessments that inform care plans and reduce the risk of inpatient and outpatient accidents. In the RCA context, PTs provide essential insights into environmental and functional contributors to medical errors. For example, a patient fall may be linked to improper assistive device use, environmental hazards, or insufficient post-surgical mobility assessment. PTs' evaluations help identify whether the underlying cause was clinical (e.g., medication-induced dizziness), organizational (e.g., inadequate staffing), or procedural (e.g., failure to assess fall risk upon admission). Moreover, PTs are instrumental in implementing proactive measures. Through early mobilization programs, strength and balance training, and ergonomic education, they reduce deconditioning and enhance independence—key strategies in fall and injury prevention. In long-term care and home-health settings, physical therapists conduct home safety evaluations, recommending modifications like grab bars or improved lighting to prevent future incidents. Their input is crucial in designing patient-centered interventions that go beyond the hospital environment, supporting the broader public health mission of injury prevention. PTs also enhance team communication by collaborating with nurses, physicians, and case managers to align rehabilitation goals with medical treatment plans. In RCA meetings, their clinical observations can pinpoint timing or coordination failures, such as delayed physical therapy referrals leading to complications or readmissions. Their expertise in biomechanics and patient handling directly supports the refinement of training protocols for healthcare workers, minimizing occupational injuries and optimizing patient transfers and mobility practices [49].

Medical Secretaries:

Medical secretaries, often regarded as administrative professionals, play a pivotal role in ensuring the smooth functioning of healthcare delivery and communication. In preventing medical errors, their work is foundational: they act as the gatekeepers of accurate scheduling, patient correspondence, record management, and interdepartmental coordination—all of which are integral to maintaining the accuracy and flow of patient information. During RCA investigations, medical secretaries provide documentation and communication logs that can clarify where information breakdowns occurred—such as missed appointment reminders, incorrect patient identification during intake, or delayed transmission of diagnostic reports. They ensure that patient demographics, consent forms, and insurance details are accurately recorded, reducing administrative errors that can cascade into clinical consequences. In addition, medical secretaries are often the first to detect discrepancies in patient records or orders. Their vigilance in cross-verifying data—such as confirming patient identity using two unique identifiers, per Joint Commission standards—helps intercept errors before they reach clinical execution. Through accurate message relay and follow-up tracking, they maintain the communication chain that supports safe care transitions, whether between providers, departments, or care facilities. Training medical secretaries in health informatics, confidentiality, and safety protocols empowers them to actively contribute to RCA and quality improvement initiatives. They bridge administrative and clinical spheres, ensuring that policies developed from RCA findings are effectively integrated into daily operations—such as standardized scheduling templates, automated reminders for lab follow-ups, and secure communication platforms that prevent message loss [49].

Collaborative Synergy: Building a Culture of Safety

When health information professionals, physical therapists, and medical secretaries work in tandem with the clinical care team, patient safety becomes embedded in every process—from documentation to rehabilitation. RCA serves as the mechanism that brings these roles together, highlighting system-level vulnerabilities and transforming lessons learned into sustainable practice improvements. Health information specialists translate data into actionable insights; physical therapists transform functional findings into preventative care; and medical secretaries maintain the integrity of administrative processes that underpin safe, coordinated care. Their combined efforts close the feedback loop between information, intervention, and communication—the triad on which safe healthcare rests. Furthermore, interprofessional education that includes these disciplines strengthens team cohesion. Training sessions that simulate RCA participation, promote communication frameworks like SBAR, and emphasize data accuracy and patient mobility create shared accountability across departments. Ultimately, enhancing healthcare team outcomes through collaboration among health information professionals, physical therapists, and medical secretaries leads to measurable improvements in patient safety, operational efficiency, and organizational resilience. As RCA continues to guide healthcare institutions toward a culture of transparency and continuous improvement, these disciplines stand as vital pillars in transforming data, movement, and communication into the foundation of error-free care [1][49].

Conclusion:

In conclusion, preventing medical error is an imperative that transcends individual clinician vigilance and requires a fundamental commitment to systemic, interprofessional safety. Root Cause Analysis (RCA) provides the essential framework for this endeavor, moving organizations beyond superficial blame to a deeper understanding of the latent conditions—flawed processes, poor communication, and technological pitfalls—that enable errors to reach patients. The true power of RCA is realized only when its findings are translated into strong, sustainable countermeasures, such as standardized protocols, engineered safety barriers, and enhanced health information technology. Ultimately, building a high-reliability organization hinges on fostering a just culture of psychological safety where every team member, from physical therapists and nurses to health informaticists and medical secretaries, is empowered to report near-misses and participate in solutions. This collaborative synergy ensures that error prevention is woven into the very fabric of healthcare delivery. By integrating rigorous RCA with unwavering leadership support and continuous monitoring, healthcare systems can transform painful adverse events into durable improvements, thereby significantly reducing preventable harm and fulfilling the ethical obligation to provide safe, high-quality care for all patients.

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