Retained Surgical Items as Emergent Systems Failure: An Integrated Multi-Theory Prevention Framework for Perioperative Settings

[1]Dr Shoeb Ahmed Ilyas., [2]Ayesha Ahmed Ilyas

[1]Medical Superintendent and Chief Operating Officer, Ekashilaa Hospital, Warangal, Telangana, India

[2]B. Tech Student, SR University, Warangal, Telangana, India

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ABSTRACT

Background. Retained surgical items (RSIs) are classified as Never Events, yet they persist despite the WHO Surgical Safety Checklist, AORN counting standards, and commercial radio-frequency identification (RFID) systems. The Joint Commission logged 119 RSI sentinel events in 2024, with 43% causing severe harm, a pattern more consistent with system pathology than individual lapse.

Objective. To develop the Integrated RSI Prevention Architecture (IRPA): a conceptual framework explaining RSI occurrence as the emergent product of simultaneous failure across cultural, human-factor, technological, and governance domains.

Methods. A structured conceptual synthesis followed Jaakkola's four-stage approach. Six databases were searched for the period 2000–2026, with seminal pre-2000 work retained; 41 sources were included in the final synthesis. Multi-theory complementarity drew on the Swiss Cheese Model, psychological safety, High Reliability Organisation (HRO) principles, Crew Resource Management (CRM), Normalisation Process Theory (NPT), and sociotechnical systems theory.

Findings: Five interlocking failure domains were identified: multi-barrier degradation, hierarchical suppression of speaking-up, checklist ritualisation, uneven RFID deployment, and accreditation regimes that audit documents rather than behaviour. The Integrated RSI Prevention Architecture (IRPA) is proposed as a conceptual, multi-theory framework that links these domains to ten falsifiable propositions and fifteen empirical gaps, with an explicit extension to perioperative settings in low- and middle-income countries.

Conclusions. RSI prevention requires concurrent investment in psychological safety, just culture, HRO leadership, and integrated technology bound together by accreditation that verifies behaviour, not paperwork. IRPA offers actionable governance recommendations for hospital boards and NABH/JCI assessors. IRPA is intended as a testable systems-safety architecture rather than a finished solution; it generates a programme of empirical work including case studies, pilot implementation projects, and registry-based surveillance to evaluate its performance in real operating theatres.

Keywords: Retained surgical item; never event; psychological safety; Swiss Cheese Model; human factors; surgical safety culture; high-reliability organisation; RFID; LMIC

INTRODUCTION

Sponges, needles, instrument fragments, and guidewires left inside a patient at wound closure are among the few surgical adverse events that nearly every surgeon, nurse, administrator, and regulator would agree should never happen. They are listed as Never Events for precisely that reason. They keep happening anyway. The Joint Commission counted 119 RSI sentinel events in 2024, severe injury in nearly half (The Joint Commission, 2024). The often-quoted population incidence of roughly one event per 10,000 procedures is based on voluntary

reporting in high-income settings and is widely held to undercount the true burden (de Vries et al., 2008). Most affected patients return to theatre; diagnosis can lag by months or years (Stawicki et al., 2013).

Persistence at this scale, despite mandated counts and the WHO Surgical Safety Checklist (SSC), points away from a gap in guidelines. A 2025 review found that most events involved items already covered by an existing count protocol; the protocol was present, but did not function. Yet institutional reflexes still gravitate toward sanctioning the individual at the sharp end, thereby leaving latent conditions intact and discouraging disclosure (Reason, 1997; Kohn et al., 2000). Reason's Swiss Cheese Model gives the underlying logic: a single retained item requires alignment of holes across several supposedly independent layers in the same operative event.

Despite that conceptual clarity, the empirical literature on RSI remains domain-siloed. Counting compliance, RFID adoption, and team communication are typically studied in isolation (de Vries et al., 2010). Psychological safety, authority gradient, checklist drift, and the governance link between accreditation and bedside behaviour rarely appear in the same model. LMIC perioperative settings, which carry the majority of global surgical volume, are almost absent from the empirical record.

This paper builds the Integrated RSI Prevention Architecture (IRPA) to bridge those silos. IRPA treats the occurrence of RSI as an emergent property that arises when six prevention domains, organisational culture, psychological safety, communication, human factors, technology, and governance, fail concurrently. The aims are threefold: to synthesise the theoretical and epidemiological foundations of RSI as systems failure; to analyse the cultural and human-factor mechanisms involved; and to translate the synthesis into ten falsifiable propositions, with explicit governance pathways for NABH/JCI-accredited and LMIC settings. This paper is intentionally developed as a conceptual work and does not generate or analyse new primary data. Instead, it employs a structured synthesis of multiple theoretical perspectives to construct a comprehensive and testable framework for future investigation. The proposed Integrated RSI Prevention Architecture (IRPA) should therefore be interpreted as a conceptual model comprising foundational propositions and guiding design principles. Its applicability and effectiveness warrant further validation through prospective research, multicenter implementation studies, registry-based analyses, and pilot testing across varied perioperative environments.

METHODS

The study is a structured conceptual synthesis, a recognised method for theory construction when the underlying evidence is large, heterogeneous, and not amenable to a single-method systematic review (Jaakkola, 2020).

Search strategy

Six databases (PubMed, Scopus, MEDLINE, Embase, CINAHL, Web of Science) were searched for January 2000–March 2026, with seminal pre-2000 work retained where it underpins contemporary safety science (Reason 1990; Edmondson, 1999; Weick et al., 1999). Boolean strings combined five term-clusters covering: (1) RSI and “never events”; (2) surgical safety and checklists; (3) psychological safety, hierarchy, and team communication; (4) human factors, CRM, and HRO; and (5) accreditation, governance, and RFID/sponge-tracking technologies. About 2,400 records were screened by title and abstract; 187 full texts were assessed for eligibility; and a final synthesis set of 41 peer-reviewed and grey literature sources was included.

Eligibility criteria

Eligible items were: empirical studies (quantitative or qualitative), systematic reviews, conceptual or theoretical articles, and authoritative grey literature from WHO, The Joint Commission, AHRQ, NHS England, and AORN that (a) addressed RSIs or closely related surgical safety events, or (b) contributed directly relevant constructs (psychological safety, CRM, HRO, sociotechnical systems, Safety-II, SEIPS) to the proposed architecture. Case reports without analytical framing, conference abstracts without full publication, non-English sources without validated translation, and commercial market reports were excluded; where possible, peer-reviewed equivalents were substituted.

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Conceptual synthesis

Jaakkola's four-stage approach for conceptual articles was applied. First, the empirical terrain was described across five domains (epidemiology, human factors and hierarchy, checklist implementation, technology, and governance). Second, causal mechanisms were explained using structured gap analysis to connect empirical regularities to underlying theory. Third, theoretical traditions (Swiss Cheese Model, psychological safety, HRO, CRM, NPT, sociotechnical systems, SEIPS, systems resilience, Safety-II) were integrated into IRPA constructs at the system, organisational, team, and individual levels. Finally, emerging propositions were debated against counter-evidence, including the Ontario checklist null result and Michigan Keystone's policy bundle success, so that IRPA's claims were explicitly set up to be falsifiable.

Gap analysis

Two patterns dominate the existing literature. First, the dominant safety tools, the Swiss Cheese Model in particular, are applied retrospectively after an event rather than prospectively to predict barrier degradation. Second, almost no published instruments link accreditation status to the behavioural mechanisms (psychological safety, escalation behaviour, observed SSC execution) through which RSI rates would actually move. LMIC contexts are conspicuous mainly by their absence.

Table 1. Structured gap analysis.

S.no	Gap	Current evidence	Limitation	IRPA contribution
1	Epidemiological surveillance	RSI ≈ 1:10,000 (Stawicki et al., 2013)	LMIC under-reporting; medicolegal suppression	Non-reporting reframed as latent system failure; GPSAP-aligned registry
2	Prospective SCM use	SCM used retrospectively (Reason, 1997)	Predictive use underdeveloped	SCM barriers mapped to observable OR variables
3	Checklist ritualisation	SSC effect (Haynes et al., 2009) vs Ontario null (Urbach et al., 2014)	No model of compliance-to-ritual drift	NPT-based ritualisation pathway (P3)
4	Psychological safety in OR	Edmondson framework; meta-analytic support (Frazier et al., 2017)	No OR-specific RSI-linked instrument	P1 specifies the operational link
5	Communication failure	Patterns identified (Greenberg et al., 2007)	Not embedded in RSI architecture	Mapped to SCM barrier collapses
6	HRO in LMICs	HRO–safety link established (Weick et al., 1999)	High-income evidence-based	Adaptable HRO–RSI architecture
7	RFID in LMICs	~75% error reduction (Carmack et al., 2023)	No LMIC-calibrated model	Staged adoption pathway
8	Accreditation–governance	RSI = Never Event	Documentary ≠ behavioural compliance	P9 links observed-practice audit to RSI
9	Risk stratification	Risk factors known (Stawicki et al., 2013)	Not embedded preoperatively	Theoretical base for risk-stratified protocols
10	Near-miss taxonomy	Reporting improves safety (Reason, 1997)	No RSI-specific taxonomy	P7 supplies the scaffold

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue V May 2026

LITERATURE SYNTHESIS

Safety science and the operating room

The modern patient safety era opened with *To Err is Human* (Kohn et al., 2000) and Reason's recasting of error as a property of systems (Reason, 1990). The WHO's Safe Surgery Saves Lives programme (2008) translated that logic into the operating room, and the Global Patient Safety Action Plan 2021–2030 extended it across seven strategic objectives (WHO, 2021). Estimates of mortality attributable to medical error remain disputed, but the order of magnitude between roughly 200,000 and 400,000 preventable hospital deaths annually in the United States is consistent with surgical harm being a leading and partly modifiable contributor (James, 2013; Makary & Daniel, 2016; Shojania & Dixon-Woods, 2017).

RSI epidemiology and clinical burden

Incidence is the figure most often quoted, but the downstream picture matters more: reoperation is common, length of stay increases, and institutional cost per event runs into the hundreds of thousands of US dollars. The high-risk profile is consistent across studies: emergency surgery, unplanned procedural change, BMI >35, multiple concurrent procedures, intraoperative team handover, and high-volume lists under time pressure (Stawicki et al., 2013). Each factor is, in effect, a structural predictor of barrier degradation. One often-overlooked clinical detail anchors the case for redundancy: intraoperative radiographs miss roughly one in three retained sponges, so imaging cannot be treated as a sufficient final safeguard.

Human factors, hierarchy, and psychological safety

Operating theatres concentrate the conditions under which speaking up is hardest: a steep authority gradient, time pressure, emotional load, and a tacit professional cost of pausing the operative flow. Edmondson's definition of team psychological safety as the shared belief that interpersonal risk is tolerated maps directly onto whether a scrub nurse will halt closure for an unresolved count. The meta-analytic evidence is now robust, with leader inclusiveness and team tenure emerging as the key moderators (Frazier et al., 2017; Newman et al., 2017).

Failures of clarification, information transfer, and authority challenge are repeatedly identified upstream of surgical injury (Greenberg et al., 2007). Crew Resource Management remains the strongest behavioural counterweight in the evidence base. Across 182 Veterans Affairs hospitals, CRM-based team training was associated with an 18% reduction in annual surgical mortality (Neily et al., 2010), and structured team processes consistently predict performance (Schmutz & Manser, 2013).

The checklist paradox

The Sign-Out phase of the WHO SSC requires explicit verbal confirmation of correct counts. Haynes et al.'s eight-country trial reported 36% fewer major complications and 47% lower in-hospital mortality with checklist use (Haynes et al., 2009). Ontario's province-wide rollout across 101 hospitals produced no detectable postoperative improvement implementation, the authors argued, was not the same as cultural adoption (Urbach et al., 2014). Michigan's Keystone Surgery evaluation reinforced that outcomes track fidelity, not paperwork (Reames et al., 2015); and recent reimplementation data show that behavioural re-engagement, not document renewal, is what restores effect (Etheridge et al., 2024).

Normalization Process Theory supplies the mechanism (May & Finch, 2009). When cognitive participation collapses under hierarchical pressure or throughput targets, collective action degrades into documentary compliance, and the Sign-Out becomes a form to be completed. IRPA labels this drift the ritualisation pathway and formalizes it in P3.

What RFID can and cannot do

RFID sponge-tracking places a passive chip in each item; a handheld wand detects retained tags before closure, and multicentre data show substantial reductions in counting error after full implementation (Carmack et al.,

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2023). The crucial point easily lost in vendor literature is that RFID detects what is physically present, not what the team believes it counted. It is also not infallible: range limits, signal interference, elevated BMI, and suboptimal patient positioning all can lead to documented false negatives. Practical barriers (consumable tag cost, sterile-processing requirements, training time, workflow disruption in emergency cases) are particularly acute in LMIC settings. The point worth carrying forward is that the same comprehensive multimodal interventions that produce a 31.7% reduction in complications consistently outperform single-technology fixes (de Vries et al., 2010).

Theoretical foundation

For readers without a background in organisational theory, the key practical takeaway is that each theory helps explain a different reason why Retained Surgical Items (RSIs) continue to occur despite established protocols, whether through failures in safety barriers, limitations in speaking-up behaviours, weaknesses in reliability culture, communication breakdowns, or gaps in learning and system improvement. Together, these perspectives show that RSI prevention depends on strengthening multiple interconnected aspects of the healthcare system rather than relying on protocols alone. IRPA integrates nine complementary traditions.

Table 2. Theory construct mapping for IRPA.

Theory	Core construct	IRPA domain	Level
Swiss Cheese Model (Reason, 1990; 1997)	Multi-barrier simultaneous failure	Structural safety layer	System
Psychological Safety (Edmondson, 1999)	Interpersonal risk tolerance	Culture	Team
HRO (Weick et al., 1999)	Collective mindfulness; preoccupation with failure	Organisational architecture	Organisation
Human Factors Engineering	Cognitive load; situational awareness	Human factor	Individual/team
CRM	Structured communication; flattened authority	Communication architecture	Team
SEIPS (Carayon et al., 2006)	Work-system × outcome interaction	Systems architecture	System
Systems Resilience	Adaptive capacity; near-miss learning	Resilience	Organisation
NPT (May & Finch, 2009)	Cognitive participation; collective action	Cultural implementation	Team/org
Safety-II (Hollnagel, 2018)	What goes right: positive safety	Positive safety layer	System

Three tensions warrant acknowledgement. The Swiss Cheese Model is retrospective, and HRO is prospective; IRPA reads them as complementary temporalities rather than rivals. Psychological safety sits at the team level and HRO at the organisational level; IRPA nests the former within the latter. Systems Resilience presumes organisational learning, yet RSI rates persist despite reporting infrastructures, so a just-versus-punitive culture is added as the moderator determining whether resilience mechanisms are operationally accessible at all.

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The Integrated RSI Prevention Architecture

Architecture

Figure 1 and Table 3 present a concise operational overview of the framework. Readers seeking a practical, implementation-focused understanding may primarily refer to these visuals along with the section on practical implications for key actionable insights. IRPA frames the retained item as the emergent product of concurrent failure across six domains: organisational culture, psychological safety, authority gradient, communication architecture, technology integration, and governance. Five moderators shape the strength of those relationships: fatigue and cognitive load, emergency case type, intraoperative handover, just-versus-punitive culture, and case complexity. Outcomes of interest are RSI occurrence (or aversion), near-miss detection rate, and team safety climate (Figure 1). For readers who prefer a more practical perspective over theoretical detail, Figure 1 may be viewed as a straightforward guide to key areas for intervention: fostering a culture that encourages speaking up, strengthening CRM-based communication practices, enhancing RFID and surgical counting systems, and ensuring accreditation processes assess actual behaviours and practices rather than documentation alone.

Figure 1 Integrated RSI Prevention Architecture (IRPA).

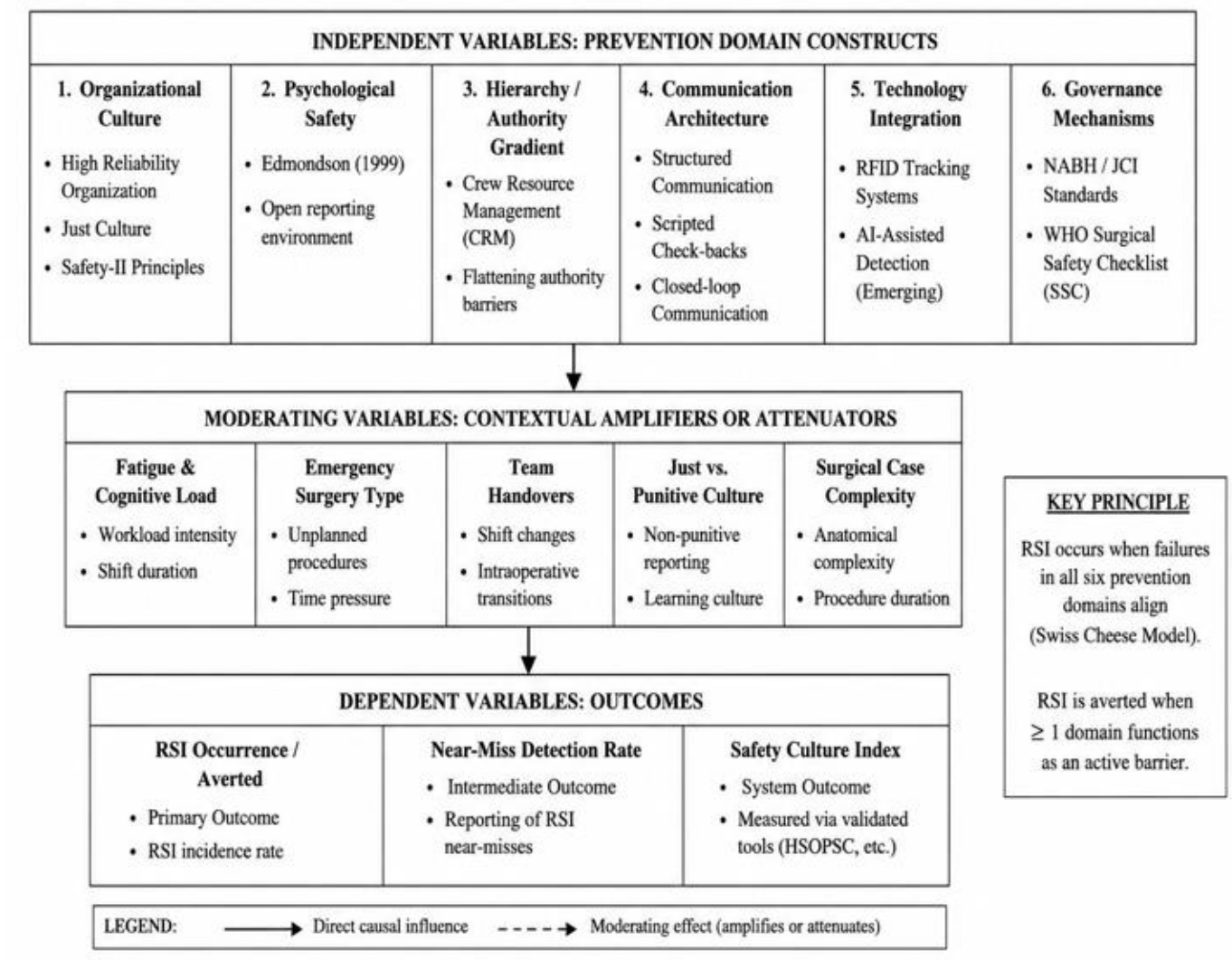


Figure 1. Integrated RSI Prevention Architecture (IRPA) exhibits that RSI occurrence is modelled as the emergent outcome of concurrent failure across six domains (organisational culture, psychological safety, authority gradient, communication architecture, technology integration, and governance), moderated by fatigue, emergency case type, intraoperative handover, just-versus-punitive culture, and case complexity. Arrows indicate where hospital boards, perioperative leaders, and accreditation bodies can intervene to restore the integrity of barriers.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue V May 2026

Propositions

The framework yields ten falsifiable propositions. Six core propositions are presented in Table 3 and discussed below; the four extending propositions fatigue moderation (P4), RFID culture moderation (P5), briefings as amplifiers (P6), and LMIC sequencing (P10) appear with their disconfirmation conditions in Appendix C.

Table 3. Core IRPA propositions.

ID	Proposition	Theoretical anchor	Predicted relationship
P1	Higher operating-theatre psychological safety is associated with more count vocalisations, lower SSC non-compliance, and lower institutional RSI incidence	Edmondson (1999); Frazier et al. (2017)	+
P2	Theatres using structured CRM communication show fewer unresolved count discrepancies than non-CRM theatres	Neily et al. (2010); Schmutz & Manser (2013)	+
P3	SSCs administered without cognitive engagement produce no RSI reduction; collective-action collapse is the mediating mechanism	May & Finch (2009). Urbach et al. (2014); Etheridge et al. (2024)	null until engagement is restored
P7	Institutions with a verified just culture (policy + survey) show higher near-miss RSI reporting and faster learning cycles	Reason (1997); Dekker (2016)	+
P8	RFID achieves maximum clinical effect in high-psychological-safety theatres because alerts are treated as binding signals	Edmondson (1999); Carayon et al. (2006); Carmack et al. (2023)	+ interaction
P9	Accreditation bodies that shift from documentary to behavioural and simulation-based audit show measurably lower RSI rates	Urbach et al. (2014). Reason (1997)	+

P1. The last human barrier rests on a single act: a scrub or circulating nurse vocalising an unresolved count while closure is in motion. Whether that act happens depends less on the protocol's existence than on the psychological conditions in which it operates, with leader inclusiveness the primary lever (Edmondson, 1999; Frazier et al., 2017). *Disconfirmation:* multi-site data show no association between validated psychological safety scores and either count vocalisation or SSC non-compliance.

P2. Psychological safety is necessary but not sufficient; a willing nurse still needs scripted, legitimised language and a clear escalation pathway, both of which CRM supplies (Neily et al., 2010; Schmutz & Manser, 2013). CRM and TeamSTEPPS are treated as equivalent behavioural pathways pending evidence from comparative trials. *Disconfirmation:* matched CRM and non-CRM theatres show no difference in count-discrepancy escalation in a prospective controlled study.

P3. The Ontario null result is the paradox NPT resolves. Where cognitive participation collapses, Sign-Out vocalisations occur without attentional engagement, and the safety pause becomes paperwork (May & Finch, 2009; Etheridge et al., 2024). *Disconfirmation:* high-throughput theatres without leader SSC modelling nonetheless achieve >90% compliance and RSI rates equivalent to behaviourally engaged theatres, indicating that compliance is achievable independent of cognitive participation.

P7. Near-misses are the principal mechanism through which safety systems learn, and just culture operationalised through both written policy and staff survey verification determines whether that intelligence surfaces or is buried (Reason, 1997; Dekker, 2016). The two-tier operationalisation matters: a non-punitive

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue V May 2026

policy can coexist with a punitive culture. *Disconfirmation:* institutions with policy- and survey-verified just culture show no difference in near-miss reporting or learning-cycle speed.

P8. RFID detects retained tags; clinical effect depends on what the team does in the next thirty seconds. In a psychologically safe theatre, the nurse who hears the alert can halt closure without professional cost. In an unsafe one, the alert is reconfirmed and overridden under closure pressure (Carmack et al., 2023; Edmondson, 1999). The cost-effectiveness implication is uncomfortable but direct: RFID procurement without concurrent investment in psychological safety yields attenuated returns. *Disconfirmation:* RFID alert compliance and post-RFID RSI rates are equivalent across high- and low-safety theatres.

P9. Documentary audits verify that a safety system exists on paper but not that it functions (Urbach et al., 2014). IRPA holds that accreditation bodies that add direct observation of Sign-Out, simulation-based assessment of team response to count discrepancies, and validated psychological-safety measurement will see measurably lower RSI rates in accredited institutions, supplementation, not replacement. *Disconfirmation:* a controlled comparison of behavioural and documentary verification shows no difference in RSI incidence or observed Sign-Out behaviour.

The six propositions form a nested architecture rather than a checklist. P1 and P2 establish the cultural and communicative substrate. P3 explains why the principal mandated safeguard fails in its absence. P7 supplies the learning mechanism. P8 specifies the technology–culture interdependence. P9 closes the loop through accreditation reform. Appendix C extends the architecture with fatigue (P4), RFID culture moderation (P5), briefings (P6), and LMIC sequencing (P10).

DISCUSSION

Protocols are not the missing piece

The Ontario natural experiment was the first large-scale demonstration that mandated checklists do not, by themselves, change outcomes (Urbach et al., 2014). IRPA resolves that paradox by locating failure in the cultural substrate: the Sign-Out degrades from a safety-enabling pause to a piece of paperwork under hierarchical pressure, throughput urgency, leader disengagement, and cognitive fatigue. Etheridge et al.'s reimplementation work confirms the corollary behavioural re-engagement, not document renewal, restores effect (Etheridge et al., 2024).

Culture versus policy is a false binary

Pronovost's Michigan Keystone study showed a near-elimination of central-line bloodstream infections through a structured policy bundle (Pronovost et al., 2006), leading some researchers to interpret this as evidence that standardised policies may have a stronger impact than organisational culture. But central-line insertion is a discrete individual task with tight feedback; RSI prevention demands sustained team interdependence across hours of surgery, where social dynamics dominate. IRPA does not reject Pronovost-style bundling; it specifies the task conditions under which culture-first sequencing becomes necessary.

Technology and culture are coupled

RFID supplies structural redundancy, but culture decides whether that redundancy is acted on. Comprehensive multimodal interventions consistently outperform single-technology fixes (de Vries et al., 2010). The board-level implication is straightforward: an RFID procurement decision should be paired with measurable investment in psychological safety, or the technology's clinical ceiling will be set by the team operating it.

Illustrative applications of IRPA in practice

Although IRPA is a conceptual framework, several published interventions illustrate how its domains operate in real-world perioperative settings. Three examples show the architecture's practical relevance without claiming that IRPA has yet been formally tested as a whole.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue V May 2026

First, checklist ritualisation. Ontario's province-wide rollout of the WHO Surgical Safety Checklist across 101 hospitals produced no detectable improvement in postoperative outcomes, despite near-universal policy adoption. IRPA interprets this as a failure of the cultural and psychological-safety substrate: Sign-Out was performed as a form-filling exercise rather than a genuine safety pause. The subsequent re-implementation work, which re-engaged teams behaviourally, supports this reading.

Second, culture-aligned policy bundles. The Michigan Keystone Surgery programme used a structured policy bundle to improve surgical outcomes, but implementation was accompanied by leadership engagement and team-based processes rather than paperwork alone. In IRPA terms, Keystone combined governance reforms with communication architecture and elements of HRO, reinforcing the idea that policy is most effective when embedded in a supportive cultural and human-factors environment.

Third, technology-culture coupling. A recent multicentre RFID sponge-tracking collaborative reported substantial reductions in counting error after full implementation, but also documented workflow and adoption challenges in theatres under time pressure and in high-BMI and emergency cases. IRPA reads these results as evidence that RFID's clinical effect is moderated by psychological safety and just culture: alerts only prevent RSIs when teams feel authorised to stop closure and treat the signal as binding.

Although these examples do not represent formal testing of the Integrated RSI Prevention Architecture (IRPA), they illustrate how real-world perioperative practices and interventions naturally align with its key domains and underlying principles. More importantly, they demonstrate that the framework is practically relevant and can serve as a useful starting point for future pilot projects, implementation efforts, and registry-based studies to evaluate its effectiveness across diverse clinical settings.

Psychological safety is infrastructure

Treating psychological safety as a soft-skills concern is a category error. It is the variable that determines whether a nurse halts closure for an unresolved count, and it is measurable through validated team surveys. Reframing it as infrastructure on the same line item as sterile processing or equipment maintenance has direct budgetary consequences and follows from the evidence rather than running ahead of it.

Accreditation reform from documents to behaviour

NABH and JCI remain the dominant accreditation regimes in India and internationally, but their current verification methods audit the presence of policies rather than their enactment. P9 describes the required redesign: direct observation of Sign-Out, simulation-based assessment of the team's response to count discrepancies, and measurement of team psychological safety as accreditation indicators. The point is supplementation, not replacement, of the existing documentary review.

LMIC perioperative settings

Most global surgery occurs in LMIC settings; most published RSI evidence does not. Resource constraints, hierarchical norms, and uneven enforcement of accreditation combine to produce a distinct risk profile. IRPA's staged implementation begins with low-cost behavioural interventions, psychological safety, CRM, just culture policy, paired with survey verification, enforced Sign-Out, before progressing to barcode-based instrument tracking and, where feasible, RFID for high-risk case categories. The available evidence that structured SSC training can raise compliance in Low- and Middle-Income Countries (LMIC) from below 40% to near-universal levels supports culture-first sequencing as both affordable and effective.

Leadership as moderator

Across the framework, surgical leadership behaviour is the single most powerful moderator. The consultant who actively invites count challenges, treats RFID alerts as binding, and responds to near-miss disclosures without blame embeds all six IRPA domains in daily practice. RSI prevention, in that sense, is a leadership performance rather than a compliance exercise.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue V May 2026

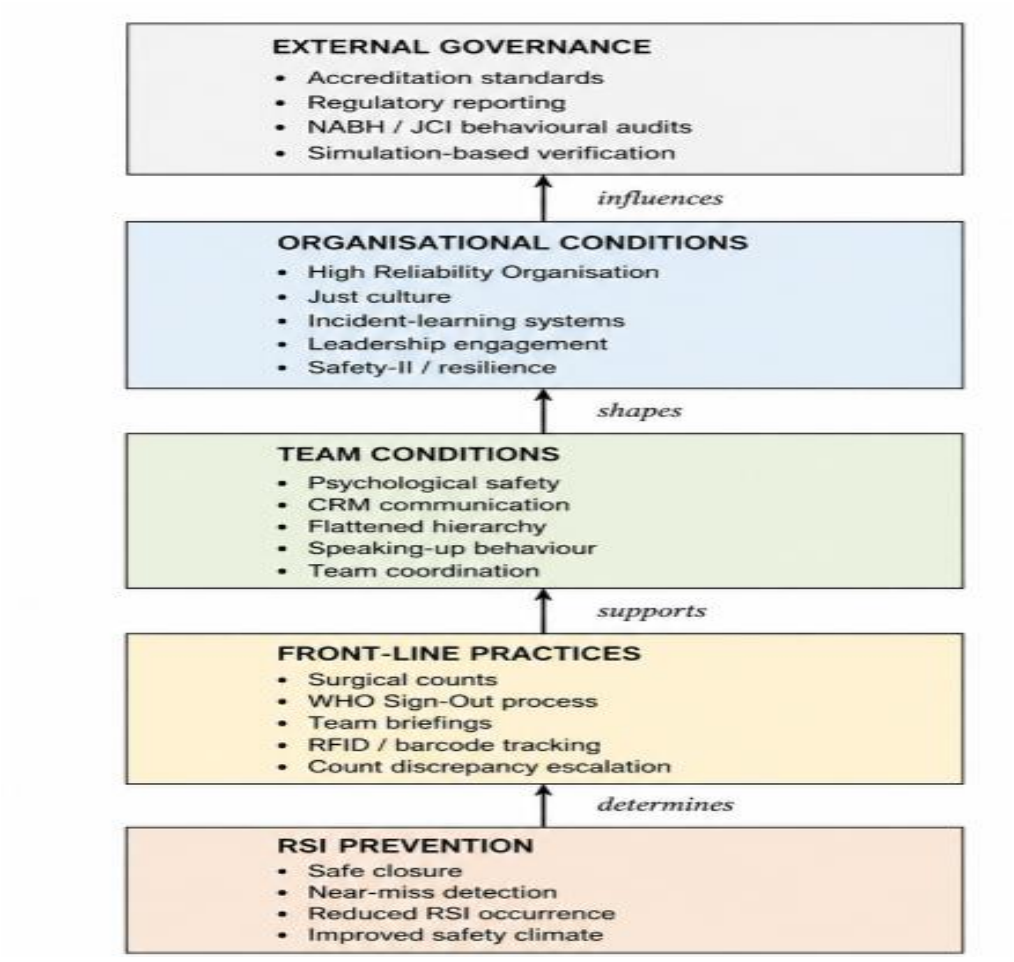
Limitations

This study is designed as a structured conceptual synthesis and does not include the collection or analysis of new primary data. Accordingly, the Integrated RSI Prevention Architecture (IRPA) should be viewed as a conceptual framework that proposes a series of testable ideas rather than a validated risk prediction model. The ten propositions and fifteen identified research gaps presented in this paper are intended to outline a future research pathway rather than provide definitive answers. Key priorities for future work include developing and validating a perioperative psychological safety scale, prospectively examining how organisational culture interacts with technologies such as RFID and barcode tracking systems, and creating robust RSI surveillance registries, particularly in low- and middle-income countries (LMIC) settings where evidence remains limited.

Practical implications

The following recommendations translate IRPA's conceptual domains into concrete actions for hospital boards, perioperative teams, accreditation bodies, training institutions, and technology investors

Figure 2. From theatre to boardroom: a simplified IRPA ladder showing how front-line practices, team conditions, organisational culture, and external governance combine to prevent or permit retained surgical items



Every layer functions as part of an interconnected safety system. Failure at one level can weaken adjacent barriers and create conditions for retained surgical items (RSIs) to emerge, whereas strengthening each layer enhances system resilience and supports sustainable perioperative safety.

The schematic illustrates how front-line clinical practices, team-level conditions, organisational culture, and external governance structures interact to prevent retained surgical items (RSIs). RSI prevention is conceptualised as an interconnected systems process in which failures across multiple levels may align and produce adverse events, while coordinated strengthening of each level restores barrier integrity and supports safer perioperative care.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue V May 2026

Hospital governance

Adopt psychological safety as a formal patient safety KPI alongside infection and readmission rates, measured quarterly through validated team instruments. Combine documentary review with behavioural observation in operating-theatre audits, and report results to clinical governance. Endorse a just culture policy at the board level, verified annually through staff survey. Require system-level (not individual-focused) root-cause analysis within 30 days of any RSI.

Operating theatre

Treat the Sign-Out vocalisation as a hard-stop closure that does not proceed until all team members confirm the count. Standardise pre- and post-operative briefings on a CRM-aligned template. Maintain a dual-count minimum standard for sponges, instruments, and sharps. Remove the hierarchical penalty attached to the count challenge and reframe it as a valued safety behaviour.

Accreditation (NABH / JCI)

Revise OT-specific verification to require direct observation of Sign-Out rather than policy review alone. It is recommended to add a validated psychological safety measure as an accreditation indicator. Require RFID or equivalent electronic tracking for high-volume institutions seeking renewal. Mandate simulation-based surgical-team safety training with role-specific competency assessment for scrub nurses, surgical assistants, and anaesthesiologists.

Training

Embed speaking-up and psychological-safety modules in undergraduate and postgraduate surgical and nursing curricula, with simulation-based assessment. Require annual CRM-based team training with RSI-specific scenarios. Include just culture and incident-reporting training in all perioperative inductions.

Technology investment

Stage RFID adoption of emergency, complex, and high-BMI elective cases first, before extension to routine work. Treat RFID alerts as a hard stop until physical verification resolves the discrepancy. In LMIC settings, explore multi-institutional procurement, government funding for health technology, and accreditation incentive programmes; deploy barcode-based instrument tracking as an interim measure when RFID is not immediately feasible.

CONCLUSION

IRPA is, to our knowledge, among the first frameworks in the patient safety literature to integrate psychological safety, the Swiss Cheese Model, High Reliability Organisation (HRO) principles, Crew Resource Management, Normalization Process Theory (NPT), Sociotechnical Systems Theory, Systems Resilience, Safety-II, and Human Factors Engineering inside a single RSI prevention architecture. Three contributions distinguish it from earlier models: psychological safety is positioned explicitly as the enabling condition under which all other safeguards operate; RSI is reframed from individual negligence to emergent systems failure, a move that is both scientifically defensible and organisationally necessary; and the architecture is extended to LMIC perioperative settings, which carry most of global surgical volume yet sit furthest from the evidence base.

The retained item is the visible outcome of a structurally deficient safety system. When the structural conditions are reversed, a nurse feels safe enough to stop surgery for an unresolved count; an RFID alert cannot be bypassed without leadership authorisation; just culture surfaces near-misses; accreditation audits behaviour rather than paper; the Swiss Cheese barriers are restored; and the event does not occur.

Future research priorities. (1) Development and validation of a Perioperative Psychological Safety Scale calibrated to RSI-relevant speaking-up behaviours. (2) Multi-site testing of IRPA propositions, prioritising P4 (fatigue × psychological safety) and P8 (RFID × psychological safety). (3) Cost-effectiveness analysis of RFID

and barcode-based tracking in LMIC settings, including NABH-accredited Indian hospitals. (4) Longitudinal comparison of CRM and TeamSTEPPS effects on near-miss reporting and RSI incidence over 24–48 months. (5) A national RSI surveillance registry in India aligned with WHO GPSAP 2021–2030 to replace voluntary-reporting undercounts.

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