



Structured Causality and Ethical Accountability through Timeline Root Cause Analysis

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Abstract – This research explores the application and efficacy of Timeline Root Cause Analysis (RCA) within organizational governance, compliance, and risk management frameworks. RCA is a structured methodology designed to move beyond superficial issue resolution by chronologically mapping causal events to identify fundamental failures. The study investigates how integrating timeline-based RCA impacts organizational resilience, ethical accountability, and operational precision. Employing mixed-method approaches across multiple case studies—including manufacturing, healthcare, cybersecurity, and labor sectors—the research validates three hypotheses: (H1) Timeline RCA significantly enhances root cause identification and mitigative response, reducing incident recurrence; (H2) RCA adoption fosters positive shifts in organizational safety culture and ethical governance; and (H3) AI-augmented digital RCA tools improve the speed and accuracy of risk management decisions. Quantitative analyses demonstrate statistically significant improvements in each domain, while qualitative findings highlight enhanced transparency, cross-departmental communication, and data integrity. Limitations include dependency on data quality, organizational culture barriers, and technology adoption costs. The results emphasize Timeline RCA as an integral governance mechanism that bridges compliance with ethical stewardship and methodological rigor. Future research should prioritize standardization of timeline approaches, leadership-driven culture change initiatives, and hybrid digital-human RCA frameworks to sustain long-term governance improvements.

Keywords – Women entrepreneurs, Work-life balance, Entrepreneurship, Female business owners, Work-life conflict.

I. INTRODUCTION

Root Cause Analysis (RCA) is a vital methodology for organizational, compliance, and governance contexts to identify and resolve underlying causes of operational failures, ethical breaches, and regulatory violations. It moves beyond surface symptoms to analyze contributing factors and systemic failures, enabling lasting corrective actions and fostering resilience [1]. This aligns with compliance-driven cultures prioritizing sustainable remediation and proactive governance [2].

A critical yet often underemphasized dimension of effective RCA is the development and adherence to a timeline for investigation, corrective actions, and verification. Establishing a structured chronology allows organizations to trace causal events accurately, highlight latency periods between incidents and responses, and benchmark the timeliness of mitigation efforts [3]. Timelines not only help teams maintain accountability but also ensure that corrective and preventive actions adhere to regulatory timeframes and auditing requirements [4]. From a compliance perspective, chronology supports defensibility during audits and legal reviews, illustrating a transparent, methodical approach to incident resolution and continuous improvement [5].

This article systematically explores RCA's multidimensional role within compliance and governance frameworks. It addresses critical questions about RCA's impact on organizational resilience and compliance sustainability, examines methodological advances and challenges, investigates behavioral and technological influences on RCA effectiveness, and considers regulatory mandates shaping RCA adoption across industries [5, 6].

Problem Statement

Despite the widespread use of RCA in compliance and governance frameworks, limited research explores the specific integration of timeline analysis as a tool for enforcing accountability and sustaining compliance outcomes. The absence of structured temporal mapping can obscure key causal relationships, delay corrective actions, and weaken organizational responsiveness to regulatory findings [3]. Without defined timelines, organizations risk inconsistent documentation, audit deficiencies, and diminished learning from adverse events, undermining long-term operational resilience [7]. Addressing this gap is essential for advancing evidence-based governance practices that connect timely RCA execution with measurable improvements in compliance and risk management performance.

Research Question and Hypotheses

How does Timeline Root Cause Analysis impact organizational compliance, risk management, and operational resilience in governance contexts?

The following hypotheses guide the investigation:

- **H1:** Implementation of Timeline RCA significantly increases the effectiveness of identifying and mitigating root causes in compliance and operational failure events.
Null Hypothesis (H0₁): Timeline RCA does not produce a significant improvement in root cause identification or mitigation.
- **H2:** Adoption of Timeline RCA positively influences organizational safety climate and compliance culture.
Null Hypothesis (H0₂): Timeline RCA does not have a positive influence on safety climate or compliance culture.
- **H3:** Integration of Timeline RCA with digital tools enhances the accuracy and timeliness of risk



management decision-making. Null Hypothesis (H0₃): Digital integration of Timeline RCA does not enhance accuracy or timeliness in risk management decisions.

Literature Review and Core Methodologies (H1)

A survey of 250 manufacturing firms [2] assessed the influence of Timeline Root Cause Analysis (RCA) on compliance incidents, employing logistic regression to model the probability of incident recurrence. The results indicated that firms adopting Timeline RCA experienced a statistically significant 30% reduction in incident recurrence ($p < 0.05$), providing strong support for the hypothesis that timeline-structured RCA improves the identification and mitigation of root causes while rejecting the null hypothesis that it has no effect [3].

Qualitative findings further uncovered that incorporating timelines into RCA investigations allowed for precise identification of not only primary root causes but also proximal causal events and critical trigger intervals, significantly enhancing traceability and the accuracy of cause-effect mapping [8]. The use of a standardized chronological framework facilitated greater cross-departmental communication, reducing misinterpretation and data silos within organizations [7]. Detailed documentation, supported by structured chronological records, also aided subsequent case analysis, employee training, and audits by building a repository of temporal patterns linked to recurring operational failures [9].

$$\log\left(\frac{\beta}{1-\beta}\right) = \beta_0 + \beta_1 X$$

The empirical validation of a 30% reduction in recurrence underscores the tangible operational benefits of Timeline RCA, demonstrating outcomes beyond theoretical assumptions [2, 9]. Timeline-based RCA outputs strengthen compliance audits, regulatory filings, and legal reviews by enhancing transparency and defensibility [5]. Importantly, by focusing on causal latency periods—the often-overlooked temporal gaps between root cause occurrence and detection or correction—Timeline RCA helps organizations target hidden vulnerabilities that conventional non-timeline RCA approaches may miss [10]. Several challenges remain in effective implementation. It demands high-quality, high-resolution data regarding event timing, dependencies, and process conditions; inadequate data quality can undermine both quantitative and qualitative analyses [11]. The complexity of temporal mapping requires trained personnel capable of interpreting sophisticated temporal data within intricate organizational systems, posing an analytical capacity barrier for some firms [12]. Resistance may arise from operational teams who perceive timeline tracking as bureaucratic or overly complex, especially in fast-paced environments, unless its direct benefits are clearly communicated and evidenced through training and leadership engagement [13].

Supporting these practical findings, systems theory conceptualizes organizations as intricate networks of interdependent processes connected via feedback loops, where failures cascade due to temporal relationships among tasks, decisions, and environmental factors [14]. Timeline

RCA capitalizes on this model by mapping causal chains chronologically to identify critical junctures for early intervention; it highlights feedback delays where corrective signals fail to reach decision-makers timely, preventing progressive degradation. By correlating event timelines with system performance metrics, Timeline RCA enhances predictive capacity and enables proactive, rather than reactive, risk mitigation strategies [15].

H2: Governance, Ethics, and Compliance

Supporting Case Study: Healthcare Safety Culture Evaluation

A mixed methods study of 180 hospital units examined the influence of Root Cause Analysis (RCA) adoption on healthcare safety culture [7]. The qualitative data revealed improvements in interdepartmental communication, collaboration across hierarchical levels, and proactive identification of potential risks [16]. Quantitative measures obtained through validated safety culture instruments demonstrated statistically significant positive shifts in perceptions of ethical behavior, transparency, and shared accountability [13]. $p < 0.01$). These results provide strong support for H2, indicating that systematic RCA implementation—especially when supported by defined timelines—enhances both organizational compliance and ethical governance outcomes [15].

The institutionalization of RCA practices contributed to measurable cultural change. Staff reported greater willingness to report errors and engage in learning-based reviews rather than punitive investigations ([17]. This shift reflects the cultivation of an ethical environment where transparency becomes both a cultural norm and a performance driver [7]. By formalizing RCA timelines, organizations established verifiable decision-making records, enabling oversight committees to identify where delays or ethical lapses occurred [14]. This traceability strengthened capacities to detect noncompliance early, promote ethical reflection, and systematically apply lessons learned [15].

Empirical evidence further underscores RCA's contribution to organizational integrity. RCA-driven accountability frameworks fostered moral consistency across departments by aligning actions with compliance objectives and ethical expectations [18]. Improvements in documentation, interprofessional communication, and situational awareness contributed to sustainable governance models prioritizing preventive ethics and continuous learning [13].

Nonetheless, several limitations were identified. Cultural resistance, especially in hierarchical environments linking error reporting to individual blame rather than systemic analysis, remains a recurrent challenge [16]. Incomplete or inconsistent RCA training reduces analytical depth and inhibits shared learning opportunities [17]. Ethical fatigue sometimes emerges when reporting systems fail to yield visible corrective outcomes, signaling the need for stronger leadership engagement and trust reinforcement in the RCA process [7].



Organizational learning theory offers a conceptual foundation for these findings, positing that ethical and compliance maturity stems from an organization's capacity to internalize feedback loops and transform error data into actionable insights [15]. When RCA becomes a continuous, reflexive learning cycle rather than episodic audit response, governance shifts from reactive compliance to proactive ethical stewardship. This integration strengthens long-term resilience, embeds moral reasoning within operational structures, and sustains governance systems that are both transparent and ethically sound [17].

Integration of Case Study Applications with H2: Governance, Ethics, and Compliance

The case study applications summarized across multiple sectors directly reinforce the findings under H2, demonstrating that Timeline Root Cause Analysis (RCA) not only supports compliance performance but also materially strengthens organizational ethics and governance practices through transparency, accountability, and continuous learning.

In contractual governance settings, timeline RCA proved essential in resolving disputes by linking causal documentation to compliance law and contractual accountability frameworks [1, 19]. The traceability inherent in timeline RCA allowed legal and compliance officers to reconstruct decision chains with precision, revealing procedural deficiencies and ethical oversights that contributed to contract failures. This application reflects the ethical governance principle central to H2—where transparent reconstruction of actions enhances fairness, accountability, and adherence to corporate integrity standards.

In the healthcare sector, RCA integration improved safety culture and compliance oversight through systematic identification of workflow bottlenecks [7, 16]. Time-structured RCA illuminated how misaligned reporting timelines and response lags suppressed frontline communication, undermining ethical responsibility toward patient safety. By embedding RCA into daily care governance processes, hospitals demonstrated how ethics-driven system learning can transform compliance from rule-following into active stewardship. This aligns with H2's emphasis on cultivating ethical awareness and shared responsibility through structured post-event analysis and training [16].

From a regulatory and cybersecurity standpoint, the Capital One breach investigations illustrated how RCA application guided policy reforms by tracing events through precise chronological mapping of system decisions and control failures [19, 20, 21]. RCA timelines exposed accountability points at both technical and managerial levels, prompting regulators to incorporate RCA-based reporting in data protection frameworks. This case directly supports H2's argument that ethical compliance evolves when organizations employ RCA not only to identify failures but

also to institutionalize integrity within regulatory governance systems [17].

In the private-sector labor context, timeline RCA informed by biometric compliance tracking helped curb violations and workplace exploitation within the fast-food industry [22, 23]. The integration of biometric timestamp systems built on RCA methodologies reinforced oversight transparency and ethical accountability, ensuring timely escalation of policy breaches and improved adherence to labor standards. This example extends the ethical dimension of H2 beyond organizational boundaries, reflecting how RCA-driven culture reforms promote corporate responsibility and moral leadership in high-turnover, compliance-vulnerable sectors.

Culture, Leadership, and Organizational Resilience

These cases collectively illustrate that institutionalizing RCA transforms ethical and compliance behavior by embedding accountability mechanisms across all levels of governance. RCA frameworks link procedural timelines to cause-and-effect accountability, encouraging leaders to frame corrective actions as ethical imperatives rather than punitive responses; as demonstrated across project management healthcare compliance [13, 18, 24]. RCA institutionalization promotes ethical resilience—the organizational capacity to learn from ethical failures and adapt governance frameworks dynamically. This transformation is consistent with organizational behavior and ethics theories [17]. Which posit that sustained ethical cultures arise when transparency, reflection, and learning become embedded in daily governance practice [4].

By connecting these cross-sector findings to H2, it becomes evident that Timeline RCA is not merely a compliance instrument but a governance mechanism that operationalizes ethics—bridging regulatory adherence with moral accountability and reinforcing the integrity of organizational systems [23].

H3: RCA, Digitalization, and Methodological Integrity

A cross-industry technology impact study involving 100 corporations evaluated the integration of artificial intelligence-enhanced Root Cause Analysis (RCA) tools within compliance and risk management frameworks [25]. Using a time-series regression model, the study assessed changes in operational response time before and after the implementation of AI-supported RCA systems:

$$Y_t = \beta_0 + \beta_1 \times \text{Post}_t + \beta_2 Y_{t-1} + \epsilon_t$$

In this model, Y_t represents the risk mitigation response time, while $\rho_{(\text{ost}_t)}$ is a binary variable identifying the implementation period of the AI-integrated RCA platform [8, 25]. The results revealed that post-implementation response times improved by 25%, confirming H3 and leading to the rejection of the null hypothesis H_{03} . This finding evidences that digital RCA tools substantially enhance operational agility and precision in risk assessment and remediation processes [19, 20, 25].



From a qualitative perspective, participating organizations reported significant improvements in decision-making speed, data accuracy, and causal traceability. The adoption of AI-facilitated RCA allowed real-time detection of pattern deviations and automated mapping of causal relationships, enabling compliance teams to forecast potential regulatory breaches before escalation. Users emphasized that automation reduced manual processing time while supporting evidence-based governance through digital audit trails [25].

Positives

AI-augmented RCA significantly enhances situational awareness by synthesizing data from multiple departments in real time, enabling organizational leaders to detect early warning signs of compliance deviations [26]. This enhanced automation reduces human error by minimizing subjective interpretations during causal categorization, leading to more consistent and accurate root cause identification [27]. Digital integration within RCA platforms supports regulatory compliance by embedding metadata, timestamped records, and procedural documentation directly into reporting workflows, thereby promoting verifiable data integrity during audits and investigations [28]. These technological advances align closely with the ethical governance objectives of RCA by reinforcing accuracy, transparency, and accountability, ultimately improving operational efficiency and strengthening organizational risk management capabilities [29].

Negatives

Despite its advantages, AI-driven RCA adoption introduces notable challenges. High initial costs in procurement, infrastructure upgrades, and user training present significant entry barriers for smaller organizations [29]. There is a risk of overreliance on automation, where analysts might undervalue experiential and contextual insights that are critical for understanding sociotechnical factors underlying compliance failures. This overdependence can compromise methodological integrity if technology replaces rather than supports human judgment [28]. To mitigate this, organizations must balance automation with human oversight to preserve analytical rigor while leveraging AI efficiency [30]. Effective implementation involves strategic planning around data quality, technology integration, and change management to maximize benefits while minimizing risks.

Supporting Theory

The Technology Acceptance Model (TAM) provides a foundational framework for understanding the factors driving successful digital adoption, including AI-enhanced Root Cause Analysis (RCA) systems [31]. TAM posits that the primary determinants of technology acceptance are perceived usefulness and perceived ease of use, which influence user engagement and sustained application. In the context of RCA, AI-augmented tools succeed when end users find them practical, reliable, and seamlessly integrated with existing compliance processes. High

usability promotes positive attitudes toward technological ethics, while enhanced data fidelity boosts stakeholder trust in analytic outcomes [32, 33].

Aligned with hypothesis H3, the digital integration of RCA and AI represents a paradigm shift toward methodological integrity, merging ethical compliance with technical precision within governance operations. Digital RCA not only expedites root cause discovery but also institutionalizes data-driven accountability, ensuring that ethical governance principles remain central to the digital transformation of compliance management [34].

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a theoretical framework developed by Fred Davis in the 1980s designed to predict and understand how users come to accept and use new technology systems [33]. It addresses the common resistance or reluctance encountered with new technology implementations by focusing on key psychological factors that influence user behavior [32].

At its core, TAM posits that two main perceptions—perceived usefulness and perceived ease of use—determine an individual's attitude toward a technology, which in turn influences their intention to use and actual usage behavior [32]. Perceived usefulness refers to the degree to which a person believes that using a specific system will enhance their job performance, while perceived ease of use pertains to how effortless the user believes the system is to operate [35].

Understanding these perceptions is essential as they directly impact user acceptance; if users find a system useful and easy to operate, they are more likely to adopt it consistently [36]. TAM provides a useful guide for designing, implementing, and promoting new technologies in various settings, including healthcare, education, and enterprise environments, ensuring higher adoption rates [37].

Integrated Research Discussion: Validation of H1, H2, and H3

The collective findings across all three hypotheses establish that Timeline Root Cause Analysis (RCA) functions as a multidimensional governance mechanism that enhances compliance reliability, ethical accountability, and operational precision. Quantitative and qualitative evidence consistently supports the transformational influence of RCA on institutional performance, confirming H1, H2, and H3 and rejecting each null hypothesis [2, 3].

In the manufacturing sector, empirical analysis demonstrated that the implementation of Timeline RCA resulted in a 30% reduction in incident recurrence rates ($p < 0.05$) [2]. This outcome validates H1 by indicating that structured causal mapping and chronological analysis effectively improve the identification and correction of system failures. Beyond incident mitigation, timeline integration enabled improved documentation quality and cross-departmental data consistency [35]. These outcomes underscore the method's role in moving organizations from



reactive troubleshooting toward predictive compliance assurance. Successful implementation depends on reliable data and skilled analysts, and resistance may occur in environments unaccustomed to process transparency. Future research should aim to standardize models to enhance RCA scalability and reproducibility across industries [38, 39, 40].

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This evidence highlights that Timeline RCA not only mitigates recurring issues but also acts as a foundational tool in building proactive governance and continuous improvement cultures within manufacturing and other operational contexts. This aligns with RCA's purpose of diagnosing true root causes rather than symptoms, thus enabling long-term systemic solutions and operational excellence [41].

CONCLUSION

Timeline Root Cause Analysis within Governance Frameworks

Timeline Root Cause Analysis (RCA) serves as a structured, evidence-based methodology that enables organizations to move beyond temporary fixes and superficial remediation efforts. By tracing failures through a chronological sequence of events and decisions, Timeline RCA isolates core causal factors, linking them directly to accountability structures, ethical responsibility, operational rigor, and proactive risk management. This temporal mapping not only clarifies what failed, but also when and

why, allowing for targeted preventive strategies rather than reactive patchwork solutions [41, 42].

When integrated into corporate governance frameworks, Timeline RCA evolves from a diagnostic tool into a strategic capability supporting compliance integrity and organizational resilience. Embedding RCA processes ensures that leadership teams can examine decisions against established ethical codes and regulatory requirements, reinforcing transparency and moral consistency. In governance contexts, this allows for an explicit linkage between behavior, process outcomes, and oversight actions, aligning operational performance with the ethical standards outlined in corporate policy [8].

Timeline RCA bolsters adaptability by creating a feedback-rich environment where lessons learned are systematically absorbed into workflows, policies, and training. This facilitates a culture of continuous improvement where stakeholder confidence grows from the demonstrable ability to prevent recurrence of incidents through structured analysis and timely intervention [26]. For regulators, investors, and clients, the presence of timeline-integrated RCA signals robust internal controls and a commitment to ethical stewardship. In high-compliance sectors—such as healthcare, finance, manufacturing, and data security—this becomes a competitive advantage as much as a governance imperative [40].

The model aligns with organizational ethics theory [17]. Which posits that ethical cultures require mechanisms that both define and reinforce norms through consistent application. Timeline RCA, when embedded into governance structures, fulfills this role by operationalizing ethical principles in day-to-day decision-making and risk evaluation. This dual focus—ethical alignment and operational precision—forms the basis for sustainable compliance and organizational resilience, ensuring that corrective actions not only resolve current issues but also strengthen the organization's long-term integrity and adaptability [38].

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