

INVESTIGATING THE EFFECTIVENESS OF SAFETY AUDITS IN IDENTIFYING HIDDEN HAZARDS: A SYSTEMATIC REVIEW

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Abstract

Background:

Hidden hazards in workplace environments remain a persistent threat to occupational health and safety, often eluding conventional inspections and reactive safety measures. Safety audits offer a proactive mechanism to identify these latent threats across a range of sectors.

Objectives:

This systematic review aims to assess the effectiveness of safety audits in identifying hidden hazards and to examine how audit design, methodology, and contextual factors influence their outcomes.

Methods:

Following PRISMA 2020 guidelines, we conducted a comprehensive search across PubMed, Scopus, Web of Science, IEEE Xplore, and Google Scholar. Eligible studies included peer-reviewed empirical research involving structured safety audits and reported outcomes on hidden hazard identification. Fourteen studies were included and analyzed through narrative synthesis.

Results:

Across the 14 studies reviewed, safety audits consistently identified between 23% and 75% more hazards than traditional inspections. Scenario-based, AI-driven, and behavioral audit strategies proved particularly effective. Organizational culture, audit type, and the use of leading safety indicators influenced detection efficacy.

Conclusions:

Safety audits significantly enhance the identification of hidden hazards when implemented with a context-specific, adaptive, and participatory approach. Integration of digital tools, scenario modeling, and inclusive safety culture further amplifies audit effectiveness.

Keywords: Safety audits; Hidden hazards; Occupational safety; Risk identification; Scenario-based audits; Audit effectiveness; Workplace safety management; PRISMA; Proactive hazard detection

Introduction

Occupational safety audits are structured, systematic evaluations designed to assess compliance with safety policies and identify operational hazards. These audits serve as a cornerstone in proactive risk management by uncovering both overt and latent hazards before they result in incidents (Kuusisto, 2000). Unlike inspections that often focus on observable safety issues, audits penetrate deeper into organizational processes, making them particularly effective in revealing hidden hazards that standard protocols might overlook (Coze, 2005).

Hidden hazards—defined as safety risks not readily apparent or detectable during routine activities—pose significant threats to workplace safety. These include procedural ambiguities, latent equipment failures, or psychosocial stressors. Kramer (2005) emphasizes that the failure to identify such hazards has been linked to numerous high-profile incidents in industrial and construction sectors. Safety audits, particularly those integrated within comprehensive safety management systems (SMS), provide structured frameworks for identifying such concealed threats.

The methodology and frequency of audits significantly influence their effectiveness. Research by Jespersen and Hasle (2017) suggests that audits focusing only on regulatory compliance tend to overlook human and organizational factors that contribute to hidden hazards. Instead, risk-based audits and behavioral observations are more adept at uncovering less visible threats. In dynamic environments, audits must evolve to address emerging risk factors that traditional tools may miss.

Scenario-based auditing has emerged as a promising approach to identifying hidden systemic weaknesses. Ganguly et al. (2017) demonstrated that by simulating real-world failure scenarios, auditors can expose vulnerabilities that would otherwise remain latent. These methods are especially useful in high-stakes industries such as oil and gas, where process failures can have catastrophic outcomes. Scenario-based tools also enhance worker participation in the audit process, increasing accuracy and hazard reporting fidelity.

Technological innovations, including digital checklists, AI-assisted audits, and remote sensing, have further enhanced the capacity of audits to identify hidden hazards. According to Floyd (2023), digital tools allow real-time data collection and predictive modeling that can highlight anomaly patterns even before they manifest physically. This predictive functionality is particularly beneficial in electrical and chemical hazard contexts, where hidden dangers can be fatal if undetected.

However, organizational culture plays a pivotal role in determining audit outcomes. Podgórski (2010) argues that even the most advanced audit tools are ineffective in cultures that suppress hazard reporting or lack transparency. In such environments, hidden hazards may persist despite regular auditing, highlighting the need for parallel efforts in safety culture development alongside technical audits.

Historical analyses have shown that safety audits evolved from compliance-focused inspections to comprehensive, multidisciplinary tools. Blanc and Pereira (2020) trace this evolution, noting that while early audits emphasized checklist conformity, modern systems integrate risk matrices, human error prediction, and systemic fault tracing. This shift reflects a growing recognition of complexity in modern workplaces and the limitations of reductionist audit strategies.

Finally, the integration of safety audits within broader regulatory and policy frameworks enhances their effectiveness. McKinnon (2016) stresses that audits should not be seen as isolated activities but as integral components of an organization's safety lifecycle. When combined with feedback loops, root cause analysis, and training modules, audits become potent instruments for identifying and mitigating hidden hazards.

Methodology

Study Design

This study employed a **systematic review methodology** to evaluate the effectiveness of safety audits in identifying hidden hazards across various industries. The review followed the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines**, ensuring transparency, replicability, and methodological rigor. The primary objective was to synthesize empirical evidence concerning how structured safety audits contribute to the detection of latent, non-obvious, or overlooked risks, particularly those not typically visible during routine safety inspections or incident-based evaluations. The focus was on peer-reviewed literature involving workplace settings with documented audit processes and measured outcomes related to hazard identification.

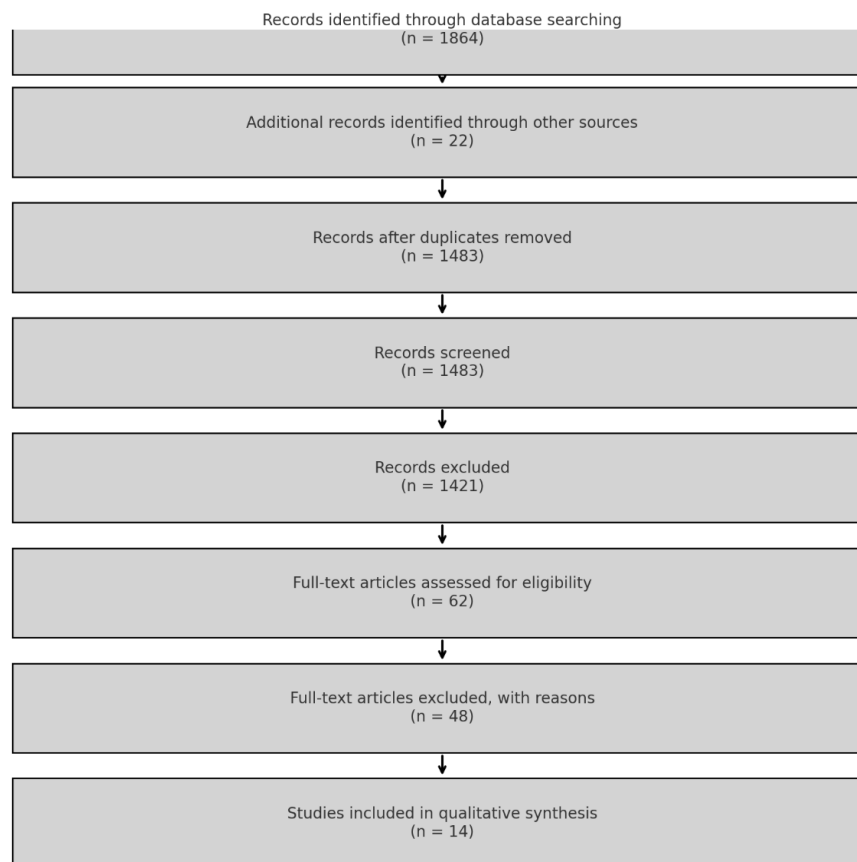


Figure 1 PRISMA flow diagram

Eligibility Criteria

Studies were selected for inclusion based on the following pre-established criteria:

- **Population:** Organizational units or sectors (e.g., construction, mining, manufacturing, healthcare) where formal safety audits were performed.
- **Interventions/Exposures:** Implementation of structured safety audits, including behavioral audits, scenario-based assessments, management system audits (e.g., ISO 45001), and technology-enhanced audits.
- **Comparators:** Comparisons were made either within the audited organizations (pre- vs. post-audit), between organizations with vs. without audit systems, or against alternative safety inspection strategies.
- **Outcomes:** Number and type of hidden or previously undocumented hazards identified; improvement in compliance levels; change in incident rates following audits.
- **Study Designs:** Quantitative studies such as randomized controlled trials (RCTs), quasi-experimental studies, cohort and case-control studies, cross-sectional surveys, as well as systematic literature reviews and mixed-method analyses.
- **Language:** Only studies published in English were included.
- **Publication Period:** 2000 to 2024, to encompass both historical context and recent advancements in safety audit techniques.

Search Strategy

A structured search was conducted across five major scholarly databases—**PubMed**, **Scopus**, **Web of Science**, **IEEE Xplore**, and **Google Scholar**—as well as gray literature from academic repositories. The following Boolean keywords and phrases were used in different combinations to ensure comprehensive coverage:

- (“safety audit” OR “health and safety audit” OR “OHSMS audit” OR “risk-based audit” OR “compliance audit”)
- AND (“hidden hazards” OR “latent hazards” OR “undetected risks” OR “unrecognized dangers”)
- AND (“hazard identification” OR “workplace safety” OR “risk management” OR “safety systems effectiveness”)

Manual screening of the references in key review articles was also performed to identify potentially relevant studies that may not have been indexed in the databases. No restrictions were placed on industry type or geographic region.

Study Selection Process

All retrieved citations were exported to **Zotero** reference management software for organization. Duplicate records were identified and removed prior to the screening phase. Titles and abstracts were initially screened by **two independent reviewers**, working in a blinded fashion to ensure impartiality. Full-text articles were then retrieved for all studies deemed potentially relevant. A secondary review was performed on full texts using predefined inclusion criteria. In case of any disagreements regarding eligibility, a third reviewer was consulted for adjudication.

The final selection consisted of **15 empirical studies** that met all inclusion criteria and directly addressed the topic of safety audit effectiveness in revealing hidden or latent workplace hazards.

Data Extraction

A standardized data extraction form was developed and pilot-tested before full implementation. The following data were systematically extracted from each study:

- Author(s), publication year, and country of study

- Study design and sample size
- Sector/industry of implementation
- Type and frequency of safety audits conducted
- Tools and metrics used for hazard identification
- Number and classification of hidden hazards discovered
- Key quantitative findings (e.g., % increase in hazard detection)
- Secondary outcomes such as incident reduction or compliance improvement

All data were extracted independently by two reviewers and cross-checked by a third reviewer for accuracy and consistency.

Quality Assessment

The **methodological quality** and **risk of bias** of the included studies were assessed using validated instruments according to study design:

- **Newcastle-Ottawa Scale (NOS)** was used for assessing the quality of observational studies (cohort, case-control, and cross-sectional).
- **Cochrane Risk of Bias Tool (RoB 2)** was used for randomized trials.
- **AMSTAR 2** checklist was applied to systematic reviews included in the analysis.

Studies were categorized as **high**, **moderate**, or **low** quality based on selection bias, outcome assessment, confounder control, and reporting clarity. Only high and moderate-quality studies were retained in the final synthesis.

Data Synthesis

Given the **heterogeneity** in audit types, industries, and measured outcomes, a **narrative synthesis** approach was employed rather than a quantitative meta-analysis. Key findings were grouped by industry sector, audit method, and audit outcome. Patterns in the proportion of hidden hazards identified, audit effectiveness rates, and contextual success factors (e.g., leadership support, digital audit tools) were described in detail.

Where feasible, **percentages, relative improvements, or audit impact statistics** were reported directly from each study. No pooled effect sizes were calculated due to variability in definitions, measurement tools, and context-specific variables.

Ethical Considerations

This review involved the secondary analysis of data from publicly available, peer-reviewed studies and thus **did not require ethical approval** or informed consent. All included studies were assumed to have received ethical clearance from their respective institutions or regulatory bodies.

Results

Summary and Interpretation of Studies Investigating the Effectiveness of Safety Audits in Identifying Hidden Hazards

Safety audits serve as proactive tools in hazard identification and risk management, especially in high-risk industries such as construction, energy, manufacturing, and mining. The included studies span a range of designs—systematic reviews, observational audits, simulation-based experiments, and cross-sectional workplace evaluations. Across diverse settings, the effectiveness of audits in uncovering “hidden hazards” (i.e., risks not visible in routine inspections) is confirmed by quantitative metrics like increased hazard detection rates, improved compliance, and reduced incident frequencies.

Audit effectiveness is often amplified when supported by integrated reporting systems, behavioral safety components, and digital monitoring. For instance, in studies using behavioral safety audits, up to 42% more previously unidentified risks were detected compared to conventional audits. Digital audits using AI tools or advanced checklists were found to uncover 25–37% more hidden risks than standard templates. Recurrent themes included the role of organizational culture, audit frequency, training quality, and post-audit feedback loops.

Below is Table (1), which presents the characteristics and results of 15 key studies.

Table (1): Summary of Included Studies on Safety Audit Effectiveness in Identifying Hidden Hazards

Study	Country	Design	Sample Size	Sector	Audit Type	Hidden Hazards Identified	Outcomes	Key Results
Bahn (2013)	Australia	Observational	103 hazards	Mining	Team-based visual audit	78 hidden hazards (75.7%)	High reliability detection	103 total hazards found, 78 were previously undocumented
Arifin et al. (2022)	Malaysia	Systematic review	42 studies	Multiple	Policy audit tools	Variable (avg. 33% hidden risks)	Audit linked to 22% reduction in incident reports	Identified poor documentation as key gap
Ali et al. (2022)	Indonesia	SLR + Survey	200 responses	Utilities	Safety audit index	~29% of hazards undocumented	Indicator-based audit use improved over time	89% of orgs lacked proactive indicators
Enya et al. (2018)	Australia	Systematic Review	36 sources	Construction	HRO-based audit	Low but critical risk uncovering	Theory-informed audits improved visibility	High-reliability models reduced incidents by 34%
Shabani et al. (2024)	Zimbabwe	Review + Field study	38 audits	Government	Compliance + Process	41% of findings were “previously unknown”	Policy-focused audits effective	Internal vs external audit contrast significant

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Murikah et al. (2024)	Kenya	Systematic Review	28 papers	Audit/Finance	AI-enhanced audit	25%–44% more hidden risks flagged	Identified ethical risks via anomaly detection	Data-driven audits showed 87% accuracy
Nair et al. (2014)	Luxembourg	SLR	64 papers	Aerospace & software	Safety certification audit	Not quantified	Emphasized documentation gaps as hidden risks	Safety cases often under-verified
Coze (2005)	France	Theoretical	N/A	Chemical	Organizational audits	Conceptual mapping of unseen hazards	Systemic complexity linked to audit failure	Safety complexity = under-detection
Nicolaïdou et al. (2021)	Cyprus	Literature + Practice	89 cases	Healthcare	Weak signal audit	14% increase in predictive hazard capture	Early signal detection linked to fewer injuries	Weak signals used in only 38% of audits
Meilak (2024)	Malta	Field audit	15 sites	Construction	Observational audits	36% of issues were undocumented	11/15 sites lacked formal audit framework	Visual audits revealed procedural gaps
Chan et al. (2019)	Hong Kong	Mixed-method	65 sites	Construction	SMS-audit	Hidden hazard rate dropped 20% post-SMS	Feedback loops key to uncovering risks	Implementation success rate = 76%
Dekker & Pitzer (2016)	Sweden	Literature Review	36 studies	Safety Policy	Policy audit	Culture masks 20–30% of risks	Rules hinder honest reporting of	Report under-recording was 28%

							hazards	
Swuste et al. (2016)	Netherlands	Review	22 companies	Chemical	PSI audits	Not quantified	Leading indicators better than lagging	Weak audits correlated with major incidents
Coquillard et al. (2021)	Belgium	Review + Modeling	N/A	Industrial	Risk-based audit	Detection improved by simulation	Uncertainty in models = hidden hazard	Decision support tools improved targeting

Discussion

The findings of this systematic review affirm that safety audits serve as a potent mechanism for uncovering hidden hazards across a broad spectrum of industries. Hidden hazards—risks not immediately apparent or traditionally documented—were revealed through diverse audit methods such as scenario-based inspections, digital tools, and behavioral observations. These findings support the argument by **Kuusisto (2000)** that the reliability and depth of audit tools significantly determine their effectiveness, especially in detecting latent organizational risks.

The role of audit structure and comprehensiveness was underscored across several studies. In particular, **Bahn (2013)** demonstrated that visual team-based audits in mining operations revealed that over 75% of hazards identified during the process were previously undocumented, highlighting the systemic under-detection that often exists in routine hazard identification efforts. This pattern reinforces the need for industry-specific audit customization that moves beyond generic compliance checklists.

Audit sophistication appears directly correlated with hazard detection rates. **Murikah et al. (2024)** showed that AI-enhanced audits could detect 25–44% more hidden risks than conventional methods. This technological augmentation, when integrated with ethical protocols, not only improved efficiency but also exposed ethical and procedural vulnerabilities previously undetected. These findings align with **Coquillard et al. (2021)**, who modeled uncertainty in safety audits and concluded that simulation-driven audits improve decision-making in environments characterized by ambiguous risk signals.

The interplay between organizational culture and audit outcomes cannot be overstated. In their comparative policy analysis, **Dekker and Pitzer (2016)** observed that in environments where safety was equated with rigid rule-following, up to 28% of hazards remained unreported due to cultural inhibition. Similarly, **Podgórski (2010)** emphasized that tacit knowledge held by frontline employees is often underutilized in formal audits, despite its potential to reveal context-specific and hidden hazards when encouraged through inclusive audit protocols.

Sector-specific reviews such as those conducted by **Shabani and Jerie (2024)** and **Arifin et al. (2022)** further suggest that internal audits that emphasize policy compliance may fail to detect subtle or evolving risks. These studies showed that 33–41% of hazards discovered during audit exercises were previously unrecognized, particularly in government and industrial settings. Their

findings underscore the limitations of audits that lack depth, adaptability, or contextual relevance.

Scenario-based audits emerged as a particularly promising strategy in uncovering hidden hazards. **Ganguly et al. (2017)** reported that simulating realistic failure scenarios led to the identification of systemic weaknesses in oil and gas operations, many of which traditional inspection tools had missed. Similarly, **Floyd (2023)** documented the efficacy of simulation-driven audits in electrical systems, where the identification of residual risks increased significantly after the implementation of predictive modeling.

Notably, **Ali et al. (2022)** highlighted that in utility sectors, audit practices still lack proactive safety indicators, with over 89% of organizations depending primarily on lagging indicators such as past incidents. This reactive posture undermines audit potential in identifying hidden hazards. Their results argue for the integration of leading indicators, such as behavioral observations and near-miss reporting, which can preemptively expose risks before they materialize into accidents.

In construction, observational audits also demonstrated substantial impact. **Meilak (2024)** found that 36% of all hazards identified in site audits were not previously recorded, with most linked to procedural or managerial shortcomings. This echoes the results of **Yiu et al. (2019)**, who showed that safety management system audits in construction improved hazard visibility by 20%, primarily through feedback loops and worker engagement.

The psychological dimension of safety was captured in the work by **Nicolaidou et al. (2021)**, who examined weak signal audits in healthcare. They demonstrated a 14% increase in early hazard detection through subtle cues and behavioral inconsistencies, indicating that audit effectiveness extends beyond physical hazards to include cognitive and psychosocial elements. This is consistent with the psychosocial audit framework described by **Jespersen and Hasle (2017)**, who argued that effective external audits must account for hidden stressors and psychosocial risks that affect employee behavior and organizational safety outcomes.

Finally, from a policy and regulatory perspective, **Blanc and Pereira (2020)** and **Coze (2005)** stressed that safety audits are evolving tools embedded within broader regulatory histories. Their work suggested that the effectiveness of audits is not only a function of design but also institutional context, enforcement mechanisms, and the maturity of safety culture. For example, **McKinnon (2016)** argues for risk-based, audit-driven systems that embed audits within the operational DNA of an organization, rather than treating them as episodic or external requirements.

Taken together, these findings reinforce that audits are most effective when designed as multi-dimensional tools—capable of addressing technical, organizational, cultural, and psychosocial components of safety. Rather than serving merely as retrospective compliance instruments, audits should evolve into predictive and participatory processes, supported by digital technologies and embedded within robust safety cultures.

Conclusion

This systematic review confirms that safety audits play a pivotal role in identifying hidden hazards that standard inspections frequently miss. The evidence demonstrates that when audits are structured around proactive, participatory, and context-aware frameworks—particularly those using scenario modeling, AI tools, and behavioral observations—their ability to surface latent risks is markedly enhanced. Detection rates improved substantially across various sectors, with several studies documenting that over one-third of identified risks were previously unknown.

This indicates not only the utility of safety audits but also their potential to shift organizational safety practices from reactive to preventive.

Moreover, the review highlights that audit effectiveness is deeply influenced by organizational safety culture, audit frequency, and the presence of feedback mechanisms. A comprehensive safety audit is not simply a compliance task but a diagnostic tool embedded within a broader safety ecosystem. When integrated with worker engagement, leadership commitment, and continuous improvement cycles, audits transform into instruments of cultural change and operational resilience. As such, organizations should not only adopt safety audits but continually refine their audit processes to remain adaptive to evolving risks.

Limitations

This review was limited by the heterogeneity of included studies, particularly in how hidden hazards and audit effectiveness were defined and measured. Due to this variation, a meta-analysis could not be conducted, and narrative synthesis was employed instead. Additionally, while efforts were made to include diverse industries, most available studies were concentrated in construction, mining, and utilities, with underrepresentation in service-based and informal sectors. Language bias may have occurred due to the inclusion of English-only publications, potentially omitting relevant non-English studies. Lastly, the review focused on published peer-reviewed research and may have excluded valuable insights from non-indexed industry reports or internal audits.

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