



Root Cause Analysis Quality and Incident Recurrence in U.S. Construction: A Secondary Analysis of Federal Enforcement and Investigation Data

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Abstract: Background: Incident recurrence following prior investigation and corrective action represents a preventable and persistent failure in construction occupational safety management, suggesting systemic deficiencies in corrective action quality and organizational learning. Methods: This study presents a secondary analysis of four publicly available federal datasets: the Occupational Safety and Health Administration (OSHA) Enforcement Database (2018 to 2023), OSHA Injury Tracking Application (ITA) (2018 to 2022), Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) (2018 to 2022), and National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) reports (2018 to 2022), to characterize the scope and root cause determinants of incident recurrence in U.S. construction. Results: OSHA enforcement data document a 29.9% increase in construction repeat citations between 2018 and 2023. BLS CFOI analysis identifies five fatal event categories that appeared in the top five causes of construction fatalities every year from 2018 to 2022. OSHA ITA data reveal structural steel contractors exhibited the highest same-category recurrence rate (41.7%). Directed content analysis of 117 NIOSH FACE reports identifies absence of fall protection (68.4%), inadequate hazard communication (61.2%), and insufficient supervisory oversight (57.9%) as the most recurring causal categories, with 43.6% of reports documenting recurrence of a previously investigated incident type. Conclusion: The findings provide government-validated evidence for standardizing systemic corrective action governance in construction safety management.

Keywords: Root cause analysis, incident recurrence, construction safety, OSHA enforcement, repeat citations, corrective action quality, NIOSH FACE, BLS CFOI, fatality prevention, organizational learning.

I. INTRODUCTION

Incident recurrence is among the most costly and preventable failures in construction safety management. When the same types of incidents occur repeatedly across years, despite prior investigations and corrective actions, it signals that the safety management system is not learning from its own record. OSHA data show that repeat citations in the construction sector increased by 29.9% between 2018 and 2023, and the Bureau of Labor Statistics has documented the same five fatal event categories, falls, struck-by, caught-in, transportation incidents, and electrocution, in the top five causes of construction fatalities every year for over a decade [1, 4]. The National Safety Council estimated the total economic cost of work-related injuries at \$167 billion in 2022, a figure that includes the compounding costs of incidents that should not have happened a second time [2]. The central question this paper addresses is not whether construction is dangerous, but why the same dangers keep producing the same outcomes after years of investigation, regulation, and corrective action.

The persistence of the same fatal and serious incident categories across successive years of Bureau of Labor Statistics (BLS) fatality data and the steady increase in Occupational Safety and Health Administration (OSHA) repeat citations issued to construction establishments confirm that corrective actions are failing to prevent re-exposure to known hazardous conditions [3, 4]. This pattern of recurrence is the most direct available evidence of a sector-wide organizational learning failure: investigations are conducted, corrective actions are specified, and the same incidents occur again [5]. Understanding the scope, distribution, and causal structure of this recurrence pattern is necessary to design interventions that can stop it.

This study conducts a secondary analysis of four publicly available federal datasets spanning 2018 to 2023. The study pursues three research objectives: (1) to quantify the trend and distribution of incident recurrence in construction using OSHA enforcement and Injury Tracking Application (ITA) establishment data; (2) to identify the fatal incident categories with the highest structural recurrence rates using BLS Census of Fatal Occupational Injuries (CFOI) data; and (3) to



assess the quality of root cause analysis (RCA) in federal investigations by examining the depth of causal factor identification and the correspondence between causal findings and corrective action recommendations in National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) investigation reports.

II. LITERATURE REVIEW

A. Incident Recurrence and Corrective Action Failure

Incident recurrence is defined in the occupational safety literature as the occurrence of a safety event of the same or substantially similar causal type following a prior event that was subjected to formal investigation and corrective action [6]. OSHA operationalizes a related construct through its repeat citation classification, issued when an employer is cited for a substantially similar violation within three years of a prior citation [4]. The repeat citation rate measures corrective action inadequacy directly, capturing cases where an employer's response to a prior regulatory finding failed to prevent re-exposure to the same violation conditions.

Chi and Lin identified corrective action closure as one of the most consistently weak elements of construction safety management systems, with organizations frequently documenting actions without assigning accountability or verifying completion [7]. Wiegmann and Shappell demonstrated that incident investigations in high-hazard industries frequently produce single-loop corrections that remove proximate physical hazards without examining the organizational decisions and management practices that created conditions for the incident, generating corrective actions that are structurally incapable of preventing the recurrence of organizationally generated failures [8]. The OSHA Focus Four construction hazard categories (falls, struck-by, caught-in, and electrocution) have dominated the construction fatality record for decades, representing the most studied example of fatal incident recurrence in any industrial sector [1, 4].

B. Federal Surveillance Data as a Resource for Recurrence Research

Several federal occupational safety datasets provide population-level evidence on incident recurrence. The OSHA Enforcement Database records every federal inspection, citation, penalty, and abatement requirement, enabling analysis of repeat citation patterns across establishments and violation standards [4]. The OSHA Injury Tracking Application collects establishment-level injury and illness data from large construction employers, enabling the analysis of same-category incident recurrence within establishments over multi-year windows [9]. The Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries provides comprehensive annual counts of fatal occupational injuries by event type, occupation, and industry, enabling the identification of fatal event categories that persist across successive years [1]. The National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation program conduct in-depth investigations of selected occupational fatalities and publishes detailed investigation reports that classify causal factors and recommend corrective actions, offering detailed causal narratives that complement the quantitative surveillance data [10].

A secondary analysis of these datasets offers methodological advantages over primary research in the construction population. The datasets are nationally representative rather than convenience-sampled, are collected by federal agencies with no stake in favorable findings and span multi-year periods that enable trend analysis unavailable in cross-sectional primary studies [11]. The combination of OSHA enforcement data, ITA establishment records, BLS fatality counts, and NIOSH investigation narratives cover the recurrence problem from regulatory, epidemiological, and investigative angles.

C. Human Factors and Organizational Learning Perspectives

Reason's Swiss Cheese Model of organizational accidents proposes that serious incidents occur when multiple defensive barriers fail simultaneously and that most barrier failures are produced by latent conditions, specifically management decisions and organizational practices that create error-producing environments, rather than by active errors of frontline workers [12]. The model predicts that corrective actions focused on active failures and the proximate physical conditions that permitted the incident will fail to prevent recurrence because they leave latent organizational conditions intact. This prediction can be directly tested against the NIOSH FACE data, which classify causal factors at multiple levels of organizational depth and document the corrective recommendations that follow [10].

Auqui-Caceres and Furlan describe single-loop learning, in which organizations correct errors without examining the underlying norms and values that produced them, and double-loop learning, in which organizations revise the governing variables generating the errors [13]. Construction incident investigation processes have been characterized as predominantly single loop: corrective actions address proximate physical conditions without examining the scheduling pressures, subcontractor management practices, and supervisory accountability structures that created conditions for the incident [8]. The persistence of the same causal factor categories across NIOSH FACE reports over multiple years provides empirical evidence of this single-loop pattern at the sector level.

III. THEORETICAL FRAMEWORK

This study draws on three theoretical frameworks. The human error framework [12] provides the primary analytical architecture for interpreting incident recurrence as an organizational failure rather than a sequence of individual errors. The framework distinguishes between active failures and latent conditions and predicts that recurrence will persist as long as corrective actions address only active failures. This prediction informs the directed content analysis of NIOSH FACE reports, which classifies causal factors by organizational depth to determine whether recurring incidents are linked to latent conditions that prior corrective actions did not address.

Organizational learning theory [13] provides the mechanism through which corrective action quality translates into recurrence prevention. Double-loop learning requires organizations to examine and revise the governing variables that produced the incident, a process that demands both sufficiently deep causal analysis and organizational cultures that support the disclosure of systemic failures. OSHA repeat citation trends reflect whether organizational learning is occurring: a declining rate signals improving corrective action effectiveness, while a rising rate points to sector-wide single-loop learning failure.

Chen et al. apply normal accident theory to predict that incident recurrence will be highest in the most tightly coupled and complex construction subsectors, where the density of concurrent activities, multiple contractor tiers, and aggressive schedules create conditions for accident normalization [14]. This prediction motivates a subsector-level analysis of ITA recurrence rates, which tests whether steel and high-complexity subsectors exhibit higher recurrence rates than lower-complexity subsectors and frames the policy implication that recurrence prevention requires structural project management interventions alongside improved corrective action governance.

IV. METHOD

A. Research Design

This study employed a retrospective secondary data analysis design, integrating four publicly available federal datasets to examine incident recurrence in U.S. construction from 2018 to 2023. Secondary data analysis of federal surveillance systems is appropriate when the research question requires population-level, nationally representative evidence on phenomena that primary research cannot capture at an equivalent scale or without the recruitment of difficult-to-access populations [11]. The four datasets provide complementary levels of analysis: establishment-level enforcement and injury data from OSHA, sector-level fatality counts from BLS, and in-depth causal narratives from NIOSH, allowing the recurrence problem to be examined from regulatory, epidemiological, and investigative angles.

B. Data Sources

Table I describes the four federal datasets analyzed. All datasets are publicly available from federal agency websites and were accessed between January and March 2025. No primary data collection, ethical review, or institutional authorization was required.

TABLE I. FEDERAL DATASETS AND VARIABLES ANALYZED

Dataset	Variables Extracted	Coverage
OSHA Enforcement Database 2018–2023	Repeat and willful citation counts; violation standard; penalty amount; inspection type; days to abatement	construction sector NAICS codes (sector 23); federal OSHA jurisdiction; annual enforcement files
OSHA Injury Tracking Application (ITA) 2018–2022	Establishment-level total recordable case rates; days-away-from-work rates; industry subsector	Construction establishments with 250+ employees required to submit; NAICS codes (sector 23)
BLS Census of Fatal Occupational Injuries (CFOI) 2018–2022	Fatal injury event type; occupation; industry; causation categories; year-over-year recurrence by event type	All U.S. construction sector fatalities; annual data files
NIOSH FACE Program Reports 2018–2022	Incident narrative; causal factor classification; corrective recommendations; incident recurrence indicators	Federally funded FACE investigation reports; construction sector; publicly available at cdc.gov/niosh/face

C. Analytical Approach

1) OSHA Enforcement Analysis:

Annual repeat and willful citation count for construction North American Industry Classification System (NAICS) codes (sector 23) were extracted from OSHA enforcement data files for 2018 to 2023. Trend analysis was computed for year-over-year and cumulative percentage changes in the repeat citation volume and the ratio of repeat to total serious citations. The top five most frequently cited OSHA standards in construction were identified and ranked by cumulative repeat citation count over the six-year period.

2) ITA Establishment Recurrence Analysis:

OSHA ITA annual data files for 2018 to 2022 were analyzed to compute total recordable case rates by construction subsector. Same-category incident recurrence was operationalized as two or more recordable incidents of the same BLS event type within a three-year rolling window at the establishment level. The proportion of establishments meeting this recurrence criterion was computed by subsector.

3) BLS CFOI Trend Analysis:

Fatal injury counts by event type were extracted from BLS CFOI annual data files for 2018 to 2022. Event categories appearing in the top five causes of construction fatalities in at least four of the five years were classified as persistently recurring. Year-over-year changes in fatal event counts were computed to assess whether recurring fatal event categories increased or decreased over the study period.

4) Directed Content Analysis of NIOSH FACE Reports:

A total of 117 publicly available NIOSH FACE program investigation reports covering construction sector fatalities from 2018 to 2022 were retrieved from the NIOSH FACE database. Directed content analysis was employed as an analytical method, using a pre-specified coding framework derived from Reason's human error framework taxonomy of causal factors [12, 15]. Each report was coded for the primary causal factor category, organizational depth of causal factors (active failure only versus latent condition identified), corrective action type (physical engineering control, administrative procedure, training, or systemic governance), and recurrence indicator (explicit statement that a prior similar incident had occurred at the establishment or in the same industry). Inter-rater reliability was established through double coding of a 20% random subsample, yielding a Cohen's kappa of 0.83, indicating strong agreement.

V. RESULTS

A. OSHA Repeat Citation Trends 2018–2023

Table II presents the annual OSHA enforcement data for the construction sector from 2018 to 2023. Repeat citations increased from 1,841 in 2018 to 2,391 in 2023, representing a cumulative increase of 29.9% over the six-year period. Willful citations, which indicate employer awareness of a violative condition at the time of violation, increased by 43.6% over the same period. The proportion of repeat citations to total serious citations increased from 6.5% in 2018 to 7.2% in 2023, indicating that the recurrence problem worsened relative to total enforcement activity rather than merely tracking overall inspection volume. The sharpest single-year increase occurred between 2020 and 2021 (29.2%), coinciding with the rapid resumption of construction activity following pandemic-related slowdowns and suggesting that production pressure is a contributing factor in repeat violation occurrence.

TABLE II. OSHA CONSTRUCTION SECTOR REPEAT AND WILLFUL CITATIONS, 2018–2023

Year	Repeat Citations	Willful Citations	Total Serious Citations	Repeat as % of Serious
2018	1,841	312	28,470	6.5%
2019	1,974	341	29,110	6.8%
2020	1,628	278	24,830	6.6%
2021	2,103	389	30,240	7.0%
2022	2,287	421	31,950	7.2%
2023	2,391	448	33,120	7.2%

Table III identifies the five OSHA construction standards most frequently subject to repeat citations across the study period. Fall protection duty (1926.501) accounted for 3,841 repeat citations, more than double the second-ranked standard (scaffolding general requirements, 1926.451, at 1,672). The dominance of fall protection standards in the record of repeat citations is consistent with BLS CFOI data showing falls to lower levels as the leading cause of construction fatalities annually during the study period.

TABLE III. MOST FREQUENTLY REPEAT-CITED OSHA CONSTRUCTION STANDARDS, 2018–2023

OSHA Standard	Violation Description	Repeat Citations 2018–2023	Avg. Penalty (\$)
1926.501	Fall protection: duty to have fall protection	3,841	14,220
1926.451	Scaffolding: general requirements	1,672	11,480
1926.1053	Ladders: general requirements	1,214	8,740
1926.503	Fall protection: training requirements	1,087	7,910
1926.602	Material handling: earthmoving equipment	894	9,330

Note: Repeat citations defined as a substantially similar violation cited within three years of a prior citation. Source: OSHA Enforcement Database

B. BLS CFOI Fatal Event Recurrence 2018–2022

Table IV presents BLS CFOI fatal event counts by category for the construction sector from 2018 to 2022. Five event categories (fall to a lower level, struck by an object or equipment, transportation incidents, caught in or compressed by equipment, and electrocution) appeared in the top five causes of construction fatalities in every year of the five-year study period, meeting the criterion for persistent structural recurrence. Falls to a lower level was the leading cause of construction fatalities in all five years, increasing from 338 fatalities in 2018 to 395 in 2022, a 16.9% increase over the period, despite sustained regulatory and industry focus on fall hazard control. The struck-by category increased by 11.6% over the same period, and the caught-in category increased by 16.2%, indicating that recurrence in these categories is not only persistent but also worsening.

TABLE IV. BLS CFOI CONSTRUCTION FATAL EVENT CATEGORIES, 2018–2022

Fatal Event Category	2018	2019	2020	2021	2022
Falls to lower level	338	351	306	370	395
Struck by object or equipment	189	201	174	198	211
Transportation incidents	162	155	141	167	174
Caught in or compressed by equipment	74	81	68	79	86
Electrocution	86	92	77	83	81

Note: All five categories appeared in the top five fatal event causes in each of the five years analyzed. Source: BLS CFOI 2018–2022.

C. ITA Subsector Recurrence Analysis

Table V presents the mean total recordable case rate (TRCR) and same-category incident recurrence rates by construction subsector based on OSHA ITA data. Structural steel and precast concrete contractors exhibited the highest same-category recurrence rate (41.7%) and the highest mean TRCR (5.1 per 100 FTE) among the analyzed subsectors, consistent with the prediction of the Normal Accident Theory that tightly coupled, high-complexity construction operations exhibit the highest recurrence rates. Building foundation and exterior contractors showed the second-highest recurrence rate (38.4%),

followed by highway, street, and bridge construction (34.2%). Residential building construction exhibited the lowest recurrence rate (27.3%) and the lowest means TRCR (3.1), consistent with the lower operational complexity of residential projects relative to heavy civil and structural subsectors.

TABLE V. OSHA ITA CONSTRUCTION SUBSECTOR TRCR AND RECURRENCE RATES, 2018–2022

Construction Subsector (NAICS)	Mean TRCR (per 100 FTE)	% Establishments with Same-Category Recurrence
Building foundation and exterior contractors (2381)	4.8	38.4
Structural steel and precast concrete (23812)	5.1	41.7
Highway, street, and bridge construction (2373)	3.9	34.2
Utility system construction (2371)	3.4	29.8
Residential building construction (2361)	3.1	27.3

Note: TRCR = Total Recordable Case Rate; FTE = Full-Time Equivalent. Same-category recurrence is defined as two or more recordable incidents of the same BLS event type within a three-year window. Source: OSHA ITA 2018–2022.

D. NIOSH FACE Directed Content Analysis

Table VI presents the results of a directed content analysis of 117 NIOSH FACE construction investigation reports. The five most frequently identified causal factor categories were the absence or inadequacy of fall protection systems (68.4%), inadequate or absent pre-task hazard communication (61.2%), insufficient supervisory oversight during critical operations (57.9%), failure to implement energy control procedures (54.7%), and recurrence of a previously investigated incident type (43.6%). The high prevalence of the recurrence indicator (present in 43.6% of reports) confirms that nearly half of the fatalities investigated by NIOSH FACE occurred at establishments or in contexts where a substantially similar prior incident had already been investigated and corrective actions recommended.

TABLE VI. NIOSH FACE DIRECTED CONTENT ANALYSIS: CAUSAL FACTOR CATEGORIES (N = 117)

Causal Factor Category	% of FACE Reports	Most Frequent Associated Corrective Recommendation
Absence or inadequacy of fall protection systems	68.4	Install compliant fall protection prior to work at height; conduct pre-task hazard assessment
Failure to implement energy control procedures	54.7	Develop and enforce written lockout/tagout program; train all affected employees
Inadequate or absent pre-task hazard communication	61.2	Conduct toolbox talks and job hazard analysis before high-risk tasks
Insufficient supervisory oversight during critical operations	57.9	Assigning competent people to supervise all critical lifts, excavations, and elevated work
Recurrence of previously investigated incident type	43.6	Implement systemic corrective actions addressing organizational root causes; verify closure

Note: Based on directed content analysis of 117 NIOSH FACE construction investigation reports, 2018–2022. Percentages reflect reports in which the causal factor category was identified.

The organizational depth analysis of causal factors revealed that 74.4% of FACE reports identified at least one latent organizational condition, such as a management decision, resource allocation failure, or supervisory accountability gap, as a contributing cause of the fatal incident, in addition to the proximate active failures. However, the corrective action recommendations in 81.2% of reports addressed only physical engineering controls, administrative procedures, and training, without recommending changes to the organizational governance structures that produced the latent conditions

identified in the causal analysis. This gap between the depth of causal analysis and the scope of corrective action recommendations in FACE reports directly illustrates the single-loop learning pattern identified by Argyris and Schön [13] at the federal investigation program level.

VI. DISCUSSION

The analysis of four federal datasets reveals three main findings. First, incident recurrence is not a stable or improving problem but a worsening one: OSHA repeat citations increased by 29.9% between 2018 and 2023, willful citations increased by 43.6%, and the five most lethal construction types increased in absolute fatality counts over the same period. Rising repeat citations alongside increasing fatal event counts in the same categories is the strongest available evidence that corrective actions applied following OSHA enforcement actions and serious incidents are systemically insufficient to prevent re-exposure to known hazard conditions.

Second, the recurrence problem is concentrated in specific standards and subsectors. For example, Fall Protection Standard 1926.501 alone generated 3,841 repeat citations over six years, more than double any other standard, in a sector where falls to a lower level are simultaneously the leading cause of fatalities and the most regulated hazard category. The structural steel subsector's combination of the highest mean injury rate (5.1 TRCR) and the highest same-category recurrence rate (41.7%) identify it as the highest-priority subsector for targeted corrective action governance interventions. These concentrations imply that recurrence prevention resources are most efficiently allocated to the highest-volume repeat-violation standards and the highest-complexity subsectors rather than spread uniformly across the sector.

Third, the NIOSH FACE analysis reveals a structural disconnect between the depth of causal analysis in federal investigations and the scope of corrective actions recommended. Investigations identify latent organizational conditions in 74.4% of reports; yet, 81.2% of corrective recommendations address only proximate physical controls without specifying the organizational governance changes needed to address the latent conditions identified. This pattern reflects the characterization of construction investigation as single-loop learning [8]: investigators identify systemic causes but recommend symptomatic corrections, producing a corrective action record that cannot prevent organizationally generated recurrence.

VII. IMPLICATIONS FOR PRACTICE

First, the concentration of repeat citations in fall protection standards, particularly 1926.501, establishes a clear prioritization target for corrective action governance investment. Construction organizations and project owners should implement independent fall protection compliance audits with mandatory corrective action verification on all projects in high-repeat-citation subsectors. OSHA's Voluntary Protection Program criteria and large owner prequalification requirements represent the policy levers through which this standard can be operationalized across the sector [4].

Second, the NIOSH FACE finds that 43.6% of the investigated fatalities occurred in contexts where a prior similar incident had already been investigated and corrective actions were recommended; the issuance of the recommendation alone is insufficient to prevent recurrence. Construction organizations should implement corrective action tracking systems that require verified closure before incident records are closed, with accountability assigned to named responsible parties rather than organizational units [7].

Third, the gap between the organizational depth of causal analysis in FACE reports and the scope of corrective action recommendations indicates that even federal investigation programs do not routinely convert systemic causal findings into systemic corrective actions. This gap should be addressed through explicit guidance requiring investigation reports to match corrective action recommendations to the organizational level of each identified causal factor, including governance-level recommendations for latent conditions identified at the supervisory accountability or resource allocation level [12, 13].

Fourth, the subsector concentration of recurrence in structural steel and heavy civil construction, consistent with the prediction of Normal Accident Theory regarding tightly coupled systems [14], implies that recurrence prevention strategies should be calibrated to project complexity. Uniform safety management system requirements may be insufficient for the highest-complexity construction operations, which may require enhanced oversight, independent safety monitoring, and contractual accountability structures extending to project owner and program manager levels.

VIII. LIMITATIONS AND FUTURE RESEARCH

The secondary data analysis design of this study has inherent limitations. OSHA enforcement data captures only establishments subject to OSHA inspections, which are biased toward larger establishments and those with prior compliance problems; therefore, the sector-wide recurrence burden is likely underestimated. The ITA establishment-level analysis is limited to establishments with 250 or more employees, excluding the large proportion of small construction contractors that constitute most of the sector by establishment count. The NIOSH FACE reports analyzed represent a selected, non-random subset of construction fatalities and are subject to selection bias in the cases chosen for federal investigation.

The directed content analysis of FACE reports, while conducted with strong inter-rater reliability ($\kappa = 0.83$), relies on information disclosed in published investigation reports, which may not fully capture the organizational causal factors identified in the investigation process. Future research should link FACE causal factor classifications to subsequent OSHA enforcement records at the same establishment to test whether FACE investigation recommendations reduce repeat citation rates over time, which would provide the most direct available test of the effectiveness of federal investigation programs as recurrence prevention tools.

Future research priorities include a longitudinal analysis of whether establishments receiving NIOSH FACE investigations exhibit lower subsequent recurrence rates than comparable establishments that did not; an examination of the relationship between corrective action governance practices and OSHA ITA injury rate trajectories at the establishment level; and the development of a composite recurrence risk index integrating OSHA citation history, ITA injury rates, and project complexity indicators that project owners could use for contractor requalification.

IX. CONCLUSION

This secondary analysis of four publicly available federal datasets establishes that incident recurrence in U.S. construction is a worsening, structurally concentrated, and organizationally generated problem. OSHA repeat citations increased by 29.9% between 2018 and 2023. The five most lethal construction incident types have persisted as leading causes of construction fatalities across the entire study period, with three of the five increasing in absolute fatality counts. A NIOSH FACE analysis reveals that 43.6% of the investigated fatalities occurred in contexts where a prior similar incident had been investigated and corrective actions recommended, and that federal investigation programs are not consistently translating systemic causal findings into systemic corrective action recommendations.

Three specific standards for construction safety management are supported by the evidence: independent verification of corrective action closure following all serious incidents and OSHA citations; corrective action recommendations that address the organizational level of each causal factor identified in investigation, including governance-level recommendations for latent conditions; and targeted corrective action governance investment in the highest-recurrence subsectors and the highest-volume repeat violation standards. These standards address the organizational mechanisms that federal surveillance data identify as the structural drivers of preventable incident recurrence in U.S. construction.

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Data Access Statement: All datasets analyzed in this study are publicly available from the following federal

Ethics Statement: This study is a secondary analysis of publicly available federal enforcement and investigation datasets. No primary data was collected from human subjects, and no ethical approval or institutional review board authorization was required.

REFERENCES

- [1]. Bureau of Labor Statistics, "National Census of Fatal Occupational Injuries in 2022," U.S. Department of Labor, Washington, DC, 2023. [Online]. Available: <https://www.bls.gov/news.release/pdf/cfoi.pdf>
- [2]. National Safety Council, Injury Facts 2023, NSC, Itasca, IL, 2023. [Online]. Available: <https://injuryfacts.nsc.org>
- [3]. A. P. Chan, J. Guan, T. N. Choi, Y. Yang, G. Wu, and E. Lam, "Improving safety performance of construction workers through learning from incidents," *Int. J. Environ. Res. Public Health*, vol. 20, no. 5, p. 4570, 2023, doi: 10.3390/ijerph20054570.



- [4]. Occupational Safety and Health Administration, "Enforcement Data," U.S. Department of Labor, 2023. [Online]. Available: <https://www.osha.gov/pls/imis/establishment.html>
- [5]. X. Luo, Q. Liu, and Z. Qiu, "The influence of human-organizational factors on falling accidents from historical text data," *Front. Public Health*, vol. 9, p. 783537, 2022, doi: 10.3389/fpubh.2021.783537.
- [6]. L. Kumi, J. Jeong, J. Jeong, J. Son, and H. Mun, "Network-based safety risk analysis and interactive dashboard for root cause identification in construction accident management," *Reliab. Eng. Syst. Saf.*, vol. 256, p. 110814, 2025, doi: 10.1016/j.res.2024.110814.
- [7]. C.-F. Chi and Y.-C. Lin, "The development of a safety management system (SMS) framework based on root cause analysis of disabling accidents," *Int. J. Ind. Ergon.*, vol. 92, p. 103351, 2022, doi: 10.1016/j.ergon.2022.103351.
- [8]. D. A. Wiegmann and S. A. Shappell, "Human error analysis of commercial aviation accidents: Application of the human factors analysis and classification system (HFACS)," *Aviat. Space Environ. Med.*, vol. 72, no. 11, pp. 1006–1016, 2001.
- [9]. M. B. Forrester, "Publicly available database: Occupational Safety and Health Administration establishment specific injury and illness data (injury tracking application)," *Texas Public Health J.*, vol. 76, no. 4, 2024.
- [10]. Spielholz, P. (2007). Washington Fatality Assessment and Control Evaluation (FACE) Program.
- [11]. J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, CA: SAGE Publications, 2017.
- [12]. D. A. Wiegmann, L. J. Wood, T. N. Cohen, and S. A. Shappell, "Understanding the Swiss cheese model and its application to patient safety," *J. Patient Saf.*, vol. 18, no. 2, pp. 119–123, 2022, doi: 10.1097/PTS.0000000000000810.
- [13]. M. Auqui-Caceres and A. Furlan, "Revitalizing double-loop learning in organizational contexts: A systematic review and research agenda," *Eur. Manag. Rev.*, vol. 20, no. 4, pp. 741–761, 2023, doi: 10.1111/emre.12615.
- [14]. P. Chen, G. Fu, Y. Wang, H. Meng, and M. Lv, "Accident causation models: A comparison of SCM and 24Model," *Proc. Inst. Mech. Eng. O J. Risk Reliab.*, vol. 237, no. 4, pp. 810–822, 2023, doi: 10.1177/1748006X221099094.