Beyond Compliance: How Safety Management Practices Shape Workplace Safety Outcomes

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ABSTRACT

Safety management practices play an important role in ensuring workplace and environmental safety. However, the practices do not rely solely on standard procedures. To prevent hazards, organizations need to provide resources, set priorities, support workers, and manage workplace conditions. The evidence on management systems and hazard prevention, leadership and employee involvement, training and communication, and the behavioural and climate pathways linking these practices to safety results is summarized in this review. Although selection effects and heterogeneous effectiveness across firm types limit causal inference, the most consistent conclusion is that organizational and group practices are associated with better safety compliance and participation. Stronger evidence for reducing injury is found for interventions that change hazards or work systems, as well as important paired observational studies of certification of occupational safety and health management systems. Safety climate is a useful leading indicator and a reliable mechanism, but it cannot be used interchangeably with injuries because studies differ in directionality, time lag, unit of analysis, and outcome source. Although training generally improves safety behaviour and knowledge, its effect on injuries varies by workplace and the controls in place. Leadership and worker involvement are important to ensure that safety practices are properly implemented. However, research evidence remains limited, particularly in studies that rely solely on questionnaires, combine different safety measures, or assess injury prevention based solely on workers' behaviour. In conclusion, safety management is more effective when different safety practices are applied together and adapted to reduce workplace risks. Worker involvement, supervision and safety performance monitoring should be given proper attention. Prolonged research periods, data from multiple sources, and consideration of differences across work sectors should be taken into account for future research.

Keywords: Safety Management Practices, Safety Outcomes, Safety Compliance, Safety Participation, Safety Performance.

INTRODUCTION

Safety management practices are organisational arrangements intended to prevent harm: leadership commitment and supervision, hazard identification and control, safety rules, training, communication, worker participation, feedback and learning. The phrase safety outcomes does not denote a single endpoint. Research commonly separates safety climate (shared perceptions of priorities), safety knowledge and motivation, compliance with required procedures, discretionary participation in safety improvement, and lagging outcomes such as recorded injuries, lost-time claims or accidents. These measures lie at different points in a hypothesised process and should not be treated as interchangeable.

The field developed from organisational safety climate research toward integrated models linking managerial action to employee behaviour and injury. Zohar's 1980 study constructed and validated a 40-item climate measure across 20 industrial organisations and related climate to inspector-rated safety-program effectiveness; workers' perceptions of management attitudes and the priority given to safety in production were especially

salient (Zohar, 1980). Early organisational models shifted attention from individual carelessness to team conditions: in one manufacturing company, Zohar's group-level study found that supervisory practices and group climate predicted micro-accident records over the following five months across 53 work groups (Zohar, 2000). Research then formalised cross-level and behavioural pathways: Hofmann and Stetzer's 21-team, 222-worker chemical-plant study linked team climate and unsafe behaviour with actual accidents (Hofmann & Stetzer, 1996); Griffin and Neal separated safety compliance from participation and proposed knowledge and motivation as intervening mechanisms (Griffin & Neal, 2000); and Neal, Griffin and Hart found that general organisational climate influenced safety climate, which was associated with both forms of safety behaviour (Neal et al., 2000).

Subsequent work tested lagged relations, leadership and organisational practice. A two-wave study linked climate, motivation and behaviour to prior and subsequent accident levels across five years; group climate predicted later individual safety motivation, while group behaviour improvements were associated with subsequent reductions in group accidents (Neal & Griffin, 2006). Zohar and Luria's multilevel model showed that organisational climate operated through group climate and that supervisors' discretion produced meaningful differences among work groups (Zohar & Luria, 2005). In the 2000s, reviews and primary studies increasingly contrasted formal systems, climate and observed injury outcomes; recent work extends this to certification, sector-specific safety programs and multilevel mechanisms. The organising argument here follows that chain: system and hazard control; leadership, participation and training; behavioural/climate mechanisms; then injuries and design limits.

METHOD AND SCOPE

The searches were conducted on 1 November 2026 across three databases: Semantic Scholar, OpenAlex and PubMed. The same general query sets were used in all three, with the following standardised strings: ("safety management practices") AND ("safety outcomes"); ("safety management practices" OR "occupational safety management practices") AND ("safety outcomes" OR "safety performance"); ("safety management practices" OR "occupational safety management practices") AND ("safety outcomes" OR "occupational safety outcomes"). Titles and abstracts were screened for relevance to occupational safety in working populations, and records were excluded when they fell outside occupational settings, were not empirical or review research, reported no relevant safety outcome, or had an unclear publication type or evidential basis. The review prioritised influential empirical studies, systematic reviews and meta-analyses, and added recent work from approximately 2021–2026. The review cites 53 distinct works; its scope is occupational safety in general, with illustrative evidence from construction, manufacturing, healthcare, agriculture, emergency services and process industries. The selection was not a formal PRISMA screening. These searches used Semantic Scholar, OpenAlex and PubMed rather than Scopus or Web of Science. Scopus and Web of Science are the databases typically used in management reviews. As a result, the retrieval may under-represent relevant management journals. Database choice can materially alter what a search returns. This is acknowledged as a coverage limitation. (Adaku et al., 2020; Marzi et al., 2024; Wanyama et al., 2021).

Management Systems Matter When They Change Hazards and Work Organisation

A central question is whether a formal safety management system itself lowers injury risk, or whether its effects depend on implementation and on the hazards it actually controls. The distinction matters because written policies and certification can be present without affecting the conditions that generate incidents. Evidence is strongest when outcomes are objective, practices are observed or audited, and comparison groups or time-series designs help distinguish program effects from pre-existing differences.

A landmark hospital study compared six management practices across 62 hospitals and found that proactive practices reliably predicted employee injury rates; reactive remediation alone did not distinguish lower-injury hospitals, and training alone was insufficient (Vredenburgh, 2002). A Spanish establishment-level analysis of 213 industrial firms found fewer injuries where prevention measures were more intensive, quality-management tools were used and workers were more empowered; the authors also identified complementary effects between organisational practices (Arocena et al., 2007). In Ontario, a cross-sectional survey of 312 manufacturing firms associated lower lost-time injury rates with worker involvement in decisions, systematic OHS recording, and stronger managerial attitudes and actions; worksites with more active worker representation on joint safety

committees also tended to have lower rates (Geldart et al., 2010). These studies converge on an implementation principle: management commitment is consequential when expressed as resources, consultation, monitoring and action on hazards, rather than as policy statements alone.

The largest matched evaluation located for system certification is an Alberta matched difference-in-differences study using firm-level compensation claims from 2000–2015. Among 14,377 OHSMS firms matched to 11,338 non-certified firms, certification was associated with a lower lost-time injury rate overall (IRR 0.86, 95% CI 0.83–0.88); the association varied by sector and firm size, with no detectable reduction in the small-firm group and no clear effect in oil and gas or forestry (McLeod et al., 2019). Its scale and claims-based outcome strengthen inference relative to employee perception surveys, but certification was not randomised and may capture firm capacity or safety maturity as well as the certification process. Later evaluations complicate this ranking: a Danish register-based follow-up found certified workplaces already had a lower risk of severe accidents two years before certification (RR 0.86, 95% CI 0.76–0.98) with no further reduction at three-year follow-up (Dyreborg et al., 2024); an updated British Columbia analysis for 2010–2021 found a diminished effect (RR 0.91, 95% CI 0.85–0.98) driven mainly by large, externally audited manufacturing firms, and suggested that earlier estimates may partly reflect selection into certification (Macpherson et al., 2025); and a 2026 Ontario evaluation found effects concentrated in larger, recently certified construction firms, noting potential unmeasured selection bias (Macpherson & McLeod, 2026). These findings do not negate the Alberta estimates, but they distinguish scale from causal strength and make pre-certification selection an important consideration when weighing the result. Smaller agriculture studies link OHSMS programming with injury or illness rates in dairy farms and compare programming levels with injury rates in poultry operations, but their small samples limit causal conclusions (Autenrieth et al., 2015, 2016).

Intervention-level synthesis clarifies why management systems do not have uniform effects. A Campbell systematic review included 100 studies (16 randomised trials, 30 controlled before-and-after studies and 54 serial-measure studies) covering 120 intervention cases; it found stronger evidence for group- and organisation-level interventions than for individual behaviour change alone, particularly when engineering or other structural controls were included (Dyreborg et al., 2022). The review reported more modest short-term effects for climate-focused approaches such as feedback or leadership training, and noted that intervention heterogeneity prevented pooling for leadership-based climate interventions (Dyreborg et al., 2022). A Dutch evaluation of safety-management and culture projects across 29 companies similarly found that outcomes depended on how interventions were designed and implemented, rather than on a single universal program component (Hale et al., 2009). The combined evidence therefore supports safety systems as a useful infrastructure for prevention, not as a treatment whose label guarantees lower injury rates.

An important distinction is between system adoption and system use. In a sample of 349 Singapore construction companies, safety-management systems were positively associated with performance, and safety incentives, subcontractor involvement and safety accountability amplified that association (Kim et al., 2019). In work groups, perceptions of climate and safety management can mediate the association between management practices and recorded injuries, with stronger mediation for recordable than for lost-time injuries(Wachter & Yorio, 2014). These results help explain why certification may show a population-level association while some small firms or sectors show little measured benefit: the system may create a management structure, but its capacity to change exposure depends on active hazard control, staffing, supervisory follow-up and worker involvement. An alternative explanation is selection into certification: in a Danish register study, adopters of certified management systems already had a 14% lower risk of severe accidents two years before certification and showed no further decrease at three-year follow-up (Dyreborg et al., 2024), and Canadian evaluations report heterogeneous effects across firm sizes and sectors, suggesting that earlier effectiveness estimates may partly reflect the selection of firms into certification (Macpherson et al., 2025; Macpherson & McLeod, 2026). Neither explanation is a tested causal account of the differences in certification; both are syntheses across studies.

The organisational implications also depend on whether the intervention changes behaviours, climate or structural conditions. The systematic review classified interventions across these levels and found stronger evidence for group- and organisation-level approaches, particularly engineering controls and multifaceted programmes that included structural measures (Dyreborg et al., 2022). In hospitals, proactive practices differentiated lower-injury organisations, while training by itself was not adequate (Vredenburgh, 2002).

Together, these findings support a prevention hierarchy in which hazard-specific structural controls are complemented, not replaced, by procedures, training and monitoring (Dyreborg et al., 2022).

Leadership, Worker Participation and Communication Turn Policy into Practice

Leadership is relevant because supervisors and senior managers determine which priorities workers see in daily production decisions. Meta-analytic evidence indicates that transformational leadership is associated with safety climate and participation, while active transactional leadership is also related to compliance and participation; climate partially explains some of these associations (Clarke, 2012). A separate meta-analysis of 33 articles and 35 independent samples found positive associations of both transformational and transactional safety leadership with worker participation, with the transformational association stronger and passive leadership showing no clear association (Zhao et al., 2022). These are broad syntheses of behavioural outcomes, not proof that leadership interventions alone prevent injuries.

Field evidence specifies how these relationships may operate. In Swedish and Danish construction, a survey of 811 workers from 85 sites assessed transformational, transactional, rule-oriented and participative leadership in relation to climate, safety behaviour and accidents; the study underscores that leadership styles should be considered jointly with formal rules and worker voice, rather than reduced to charisma or compliance enforcement (Grill et al., 2017). In Malaysia, a two-wave multilevel study of 317 firefighters across 46 stations found that supervisory and coworker safety support mediated the relationship between climate and compliance/participation, making day-to-day social support a plausible transmission mechanism (Syed-Yahya et al., 2022). A 2022 study of mining enterprises in China likewise examined safety-management leadership in relation to employee performance (Shu et al., 2022), and a 2023 petroleum-enterprise study of 630 employees in 66 teams tested the sequence from team transformational leadership through climate and motivation to safety behaviour (Wang et al., 2023).

Participation is not a decorative supplement to formal systems: it provides local hazard information and helps workers adapt procedures to real tasks. In manufacturing, a survey of 312 Ontario firms linked worker decision involvement and stronger worker representation in safety committees with lower lost-time injury rates (Geldart et al., 2010). A Malaysian SME study of 74 employees found that management commitment, training and rules/procedures were associated with compliance, and that participation mediated some relationships between management commitment/training and compliance; because the study was small and cross-sectional, it supports a pathway hypothesis rather than causal mediation (Subramaniam et al., 2016). A study of 68 Malaysian industrial companies using three years of injury records reported associations between a bundle of management practices and musculoskeletal injury rates; however, its abstract describes the overall relationship as significant while printing a p-value that conflicts with that interpretation, so its result should not be treated as definitive (Ali et al., 2009).

Communication and feedback work when they make hazards visible and close the loop between reporting and corrective action. In the classic analysis of 62 hospitals, communication/feedback was among the proactive practice dimensions predicting injury rates, but training alone did not suffice (Vredenburgh, 2002). A 2021 systematic literature review of 24 papers found that safety research had predominantly used quantitative approaches and had commonly examined management commitment, safety rules and procedures, and training (Malaysia et al., 2021). The synthesis is that leadership and worker involvement are complementary: top-down priority supplies legitimacy and resources; worker voice supplies task-specific knowledge and feedback. Neither is likely to work reliably if production pressure (Bosak et al., 2013), inadequate staffing (Trinkoff et al., 2005) or equipment failure (Bourassa et al., 2015) make safe work impracticable.

This complementarity is also a multilevel issue. Organisational climate and group climate can be aligned overall but vary across supervisors because local discretion changes how formal procedures are enacted (Zohar & Luria, 2005). A supervisor who discusses hazards, responds to reports and reinforces procedures may therefore shape the workgroup's shared expectations more directly than an abstract corporate policy (Zohar & Luria, 2005). Conversely, a participatory process without authority or resources to correct hazards can produce voice without control, a concern consistent with the observed relationship between committee composition, executive functions and injury rates (Geldart et al., 2010). Evidence from safety committees and SMEs suggests that

worker participation is most likely to be a route to prevention when management attends meetings, records OHS concerns and links discussions to real decisions (Geldart et al., 2010; Subramaniam et al., 2016).

Leadership effects should also not be collapsed into a single "good leader" score. Transformational leadership can support discretionary participation and climate; active transactional leadership can reinforce clear standards and compliance (Clarke, 2012). In construction, rule-oriented and participative leadership styles were assessed alongside transformational and transactional styles, reflecting the practical need to maintain reliable controls while inviting local adaptation (Grill et al., 2017). This body of evidence favours a combined approach that includes clear, non-negotiable safeguards plus consultation and learning rather than a choice between strict rules and employee autonomy. The specific balance likely depends on hazard severity, standardisation and the work's need for rapid adaptation; those moderators require direct testing. Until such moderators are examined in controlled designs, the claim that a balanced mix of standards and participation improves outcomes should be treated as a working hypothesis supported by convergent correlational and meta-analytic evidence rather than an established causal mechanism (Clarke, 2012).

Training and Rules Improve Capability, but Need Hazard Control and Opportunity to Comply

Training has a clear proximal purpose: improve knowledge and skill, and the strongest synthesis found training improved safety knowledge, climate, motivation, compliance and participation (Hutchinson et al., 2021). The more difficult issue is whether this translates into fewer injuries, which depends on the hazard, the task, the quality of instruction and the surrounding work system. A meta-analysis of 100 unique samples from 90 reports found effect sizes ranging from $d = 0.25$ for participation to $d = 0.87$ for knowledge, while the moderating effect of industry risk level was not consistent across outcomes (Hutchinson et al., 2021). A 2025 meta-analysis drawing on 157 independent studies similarly reported much larger effects on learning ($\delta = 1.18$) than on overall safety indicators ($\delta = 0.26$), a converging pattern in which the benefits of training weaken as outcomes shift from proximal knowledge to distal safety results, although its outcome categories are not identical to those of the earlier synthesis (Bisbey et al., 2025). A training evaluation in Italian mechanical firms used multiple sources—questionnaires, knowledge tests and observations—before and after scheduled training among 109 workers, illustrating a stronger measurement strategy than reliance on a single self-report measure (Ricci et al., 2022).

Trial evidence shows why interactive and participatory methods are promising but not uniformly decisive. A cluster-randomised trial in Shenzhen compared participatory training for 918 workers with didactic training for 907 workers in the same factories and matched controls totalling 1,654 workers (Yu et al., 2017). An earlier report of the same trial followed 3,479 frontline workers in 60 factories and compared participatory with didactic training using work-injury data over the prior year and one year after training (Yu et al., 2011). This trial improves causal confidence over cross-sectional surveys, but the evidence remains bounded to its factory settings and training formats. In a study of 2,358 U.S. establishments, safety training was associated with more injury and illness reporting as well as fewer days-away outcomes, suggesting that reported incident counts can rise as reporting improves even as more severe outcomes fall (Waehrer & Miller, 2009). This is an important measurement caveat: an increase in reported incidents does not necessarily mean worsening safety.

Rules and procedures provide a standard for known risks, but they cannot anticipate every work condition. A review of organisational controls distinguishes compliance from violations and circumvention, emphasizing that prescribed rules need to be complemented by social and self-controls (Reason et al., 1998). Safety behaviour is also multidimensional: an early study across 828 manufacturing workers found that compliance with safety rules did not form a consistent unitary dimension, while safety initiatives had strong measurement reliability and relevance to accident prevention (Marchand et al., 1998). In construction, a meta-analysis of 11 studies drawn from a review of 107 found associations between safety performance and supervisor safety role ($r = .30$), management commitment ($r = .27$), rules and procedures ($r = .25$), individual responsibility ($r = .23$) and training ($r = .10$) (Alruqi et al., 2018). These coefficients are correlations across different underlying studies and measures, not comparative intervention effects; they suggest the relative salience of measured climate dimensions, not that training is ineffective.

A contemporary leadership-training intervention in three wood-processing companies combined management education, safety observations, feedback, judgment setting, and low-cost rewards, providing a pragmatic test of

an integrated approach in smaller firms (Moon, 2024). Evidence from small firms remains particularly important because resource constraints may limit training quality, specialist safety capacity and access to engineering controls. The judgment across studies is that training is an enabling component, most likely to influence safety when it is task-specific, participatory and reinforced by adequate equipment, realistic procedures, coaching and managerial follow-through.

Griffin and Neal's framework identifies safety knowledge and motivation as mediators between climate and safety performance (Griffin & Neal, 2000). Workers can know a procedure but be unable to follow it when equipment is unavailable, production targets conflict with safety or a rule is poorly adapted to the task; job/task and organisational barriers were influential in a study of nurses' adherence to universal precautions (DeJoy et al., 1995). A study of universal-precaution adherence among 451 nurses found that job/task and organisational factors were the strongest predictors, and proposed access to protective equipment, reduction of work hindrances and improved safety feedback as complementary intervention elements (DeJoy et al., 1995). This is consistent with the broader intervention evidence: training improves proximal outcomes such as safety knowledge and behaviour (Burke et al., 2011) but cannot reliably compensate for a hazardous physical or organisational environment (Dyreborg et al., 2022). Training effects should therefore be judged not only by attendance and knowledge scores but by observed practice, work conditions and subsequent harm.

Rules provide formal controls, but their behavioural effects depend on how workers interpret and enact them; organizational-control research distinguishes compliance from violations and circumvention (Reason et al., 1998). Safety behaviour measurement likewise separates compliance from safety initiatives, and evidence from 828 workers across nine Quebec manufacturing facilities found that compliance was not a consistent unitary construct (Marchand et al., 1998). This supports measuring specific forms of compliance and discretionary safety initiatives separately rather than inferring one from the behaviour. Such a distinction also matters for interpreting safety climate, since safety climate relates more strongly to discretionary participation than to mandated compliance, while its link to subsequent accident involvement is weaker and less consistent (Clarke, 2006).

Climate, Knowledge, Motivation and Behaviour are Pathways, not Final Outcomes

Safety climate captures workers' shared perceptions of whether management prioritises safety in practice. It is both an outcome of management signals and a potential mechanism linking those signals to behaviour. The foundational framework from Griffin and Neal treats safety climate as an antecedent to safety knowledge and motivation, which in turn support compliance and participation (Griffin & Neal, 2000). This distinction is analytically useful: compliance describes required safe conduct; participation captures discretionary contribution, such as reporting hazards or helping improve the system. The two behaviours are related but not interchangeable, and a workforce can comply with rules without actively contributing to prevention.

Meta-analyses broadly support climate as a predictor of behaviour, but the climate–injury link is less direct. Clarke's meta-analysis found relationships between organisational climate and both compliance and participation, with the stronger relationship for participation, while the subsequent relationship with accidents was weak; prospective designs were more informative than concurrent measures (Clarke, 2006). Christian and colleagues' meta-analysis found that safety knowledge and motivation were strongly related to safety behaviour, while group climate showed the strongest association with accidents and injuries among the situational antecedents examined (Christian et al., 2009). Beus and colleagues found that injuries predicted organisational climate more strongly than climate predicted injuries, with measurement contamination and time-window choices affecting observed relationships (Beus et al., 2010). Taken together, the syntheses warn against a one-way model: safety climate can influence behaviour, while injury experience can also alter behaviours of management and safety priorities.

Primary studies provide support for proposed mediators while showing the need to match outcome and design. In 1,566 workers from eight major-accident-hazard process units in Kerala, Vinodkumar and Bhasi found that selected management practices related directly and indirectly to safety performance through knowledge and motivation (Vinodkumar & Bhasi, 2010). In 3,970 Chinese manufacturing workers across 42 firms, climate, safety behaviour, and prior-year injuries were associated (Jiang et al., 2009), with path analysis linking safety behaviour and perceived colleagues' safety knowledge to injuries and near misses; the cross-sectional design

cannot establish directionality. A prospective study of 419 workers in 34 restaurants measured management commitment and training perceptions before future injury, offering a more appropriate temporal ordering for climate-outcome inference (Huang et al., 2012). In another restaurant study, researchers surveyed 349 workers across 30 restaurants, directly observed slip-resistant shoe use and followed slips weekly for 12 weeks, linking organizational climate with an observed safety practice and subsequent hazard-specific events (Swedler et al., 2015).

Recent multilevel work has made the mechanisms more specific. A two-wave lagged study of 1,089 Italian workers in 143 teams measured supervisor and coworker climate, knowledge, motivation, compliance, participation and accidents a year later; its design incorporates group context and autoregressive effects, although its abstract reports mixed support rather than an unqualified pathway (Brondino et al., 2025). In 2022, a longitudinal Malaysian fire-and-rescue study of 317 firefighters in 46 stations tested supervisor and coworker support as mediators over a six-month interval (Syed-Yahya et al., 2022). Recent mediation studies confirm that safety motivation mediates the link between safety climate and safety performance (BAĞIRAN & ERÇETİN, 2026). These studies support a layered account: organisation-level priorities are interpreted by supervisors and teams, shaping individual knowledge, motivation and opportunities to act. The evidence does not establish that every mediating path is universal; cross-sectional mediation and model fit should not be mistaken for experimentally verified mechanisms.

Griffin and Neal's framework separates safety climate from the knowledge and motivation that mediate its links with safety performance, giving researchers a basis for testing why a management practice may affect some outcomes more than others (Griffin & Neal, 2000). A training meta-analysis found its largest effect for safety knowledge ($d = 0.87$) and smaller effect for participation ($d = 0.25$), illustrating that gains in capability and discretionary behaviour are not equal in magnitude (Hutchinson et al., 2021). A larger 2025 meta-analysis of 157 studies likewise found stronger effects for learning ($\delta = 1.18$) than for overall safety indicators ($\delta = 0.26$), although its outcome categories and effect-size metrics differ from those of the earlier analysis, so the estimates are not directly comparable (Bisbey et al., 2025). In U.S. establishment-level data, training was associated with increased reporting of injuries and illnesses but also with reductions in days-away outcomes, showing that reporting and severity measures can move differently (Waehrer & Miller, 2009). These findings support separating knowledge from compliance and participation in outcome measurement (Griffin & Neal, 2000; Hutchinson et al., 2021). Researchers should specify which pathway is expected, who is exposed to the practice, and how long a change should take to appear in the selected outcome.

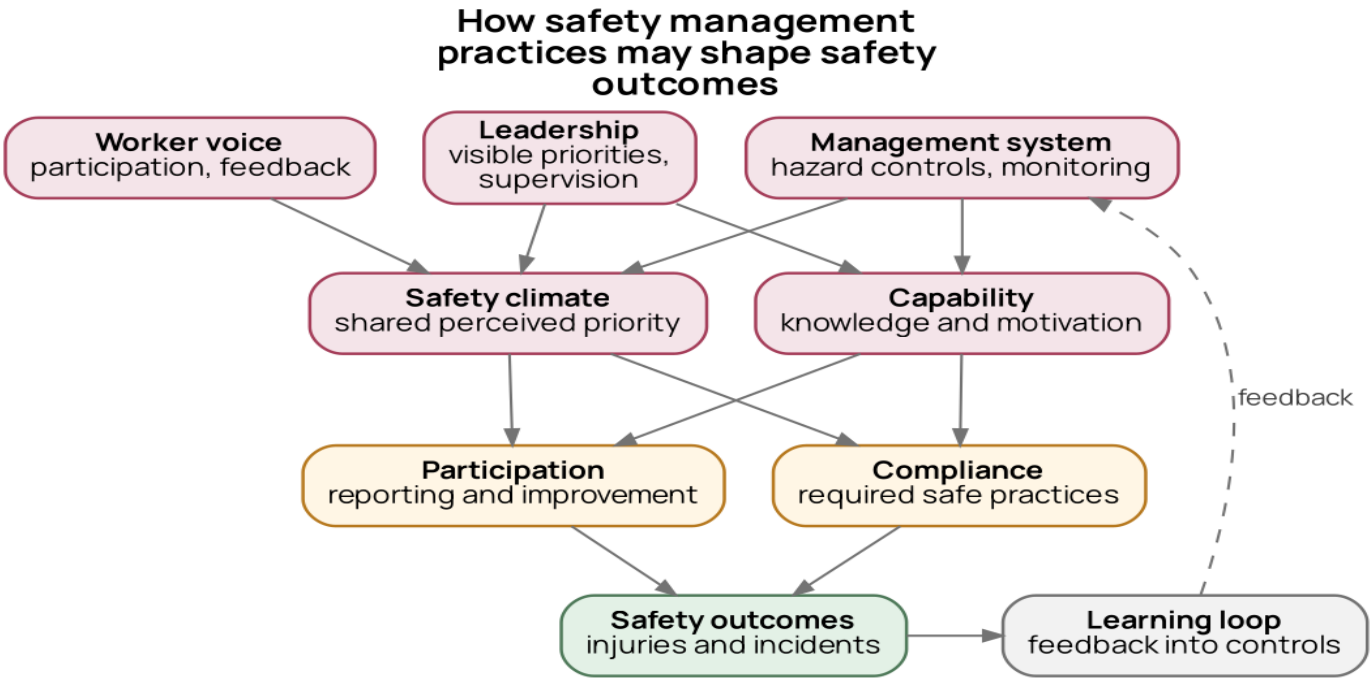


Figure 1: How Safety Management Practices Shape Safety Outcomes

Conceptual pathway from management practices through climate, capability and behaviour to safety outcomes. Solid arrows represent relationships tested or supported in the cited literature; the dashed feedback loop is a proposed learning pathway. Management practices relate to climate and behaviour (Griffin & Neal, 2000; Neal et al., 2000), while climate and behaviour have prospective or meta-analytic links to injury outcomes (Clarke, 2006; Neal & Griffin, 2006).

Injury Outcomes, Sector Variation and the Strength Inference

The most consequential question is whether better management practices reduce actual harm. In a study of 53 work groups within one manufacturing company, group-level safety climate predicted micro-accident records during a subsequent five-month period (Zohar, 2000). In two otherwise similar manufacturing plants, the plant with lower climate scores also had roughly twice the self-reported injury rate and nearly 30% higher lost-time injury incidence at baseline; changes over time were examined following a workplace-improvement project (Nielsen et al., 2007). In a large Chinese manufacturing sample, safety climate and behaviour were related to prior-year injuries, though the cross-sectional measurement makes the direction of effects ambiguous (Liu et al., 2015). These studies collectively show that organizational perceptions and behavioural measures are related to injury indicators, but only prospective and intervention designs can more credibly establish whether management change precedes fewer injuries.

The relation is sector-specific. In healthcare, a Veterans Health Administration analysis evaluated six program and climate categories against employee injury rates, extending climate research beyond manufacturing (Cook et al., 2016). In the fire service, a study of 398 professional firefighters found climate associated with both safety compliance and participation and examined their relationships with line-of-duty injuries (Smith & DeJoy, 2014). A study of 25 commercial construction companies in Colombia examined the association between workers' safety-climate perceptions and safety-management practices reported by safety officers, treating climate as a parallel workplace outcome rather than assuming it only causes injuries (Marín et al., 2017). In 2025, an Ethiopian study of 1,203 workers across 22 large construction sites assessed climate and performance using NOSACQ-50, reporting low climate scores and a positive association with performance (Abegaz et al., 2025). A related report from the same setting and sample size examined safety behaviour and self-reported injuries, so these two reports should not be counted as independent replications (Abegaz et al., 2025a, 2025b).

A cross-sectional study in the Korean working population assessed safety climate and occupational injury, and a U.S. Air Force study linked voluntary climate surveys from 2014–2018 with injury events across maintenance, support and operations occupations (Min et al., 2024; Socias-Morales et al., 2023). The Air Force design's administrative injury linkage is a methodological strength, but voluntary survey participation and observational associations still limit causal claims. A 2022 study of marble-industry workers in Turkey similarly connected climate with performance and occupational accidents (Gümüş et al., 2022). In India's Kerala state, a cross-sectional study of 1,566 employees in eight major-accident-hazard process units associated selected management practices with knowledge, motivation, compliance and participation; a Malaysian SME study explored practice–behaviour pathways in a different organisational context (Subramaniam et al., 2016; Vinodkumar & Bhasi, 2010). These studies provide regional and sectoral range, but common-method bias and non-random selection remain concerns for many survey-based results.

Table 1: Methodological Comparison

Evidence source	Design and setting	Outcome and principal contribution	Main inferential limit
Vredenburgh (2002) (Vredenburgh, 2002)	Management practices and injury data across 62 hospitals	Proactive practices predicted injury rates; training alone was insufficient	Observational organisational comparison
Ali et al. (2009). (Ali et al., 2009)	68 Malaysian industrial companies; three years of injury data	Feedback and participation were associated with injury rates; overall model reported behaviour	Small injury event count and inconsistent statistical signal

Geldart et al. (2010). (Geldart et al., 2010)	Cross-sectional survey of 312 Ontario manufacturing firms	Worker participation and managerial OHS engagement associated with lower lost-time rates	Cross-sectional exposure/outcome assessment
Vinodkumar & Bhasi (2010) (Vinodkumar & Bhasi, 2010)	Survey of 1,566 process-industry employees in Kerala	Management practices related to knowledge, motivation and safety behaviour	Self-report and correlational model
McLeod et al. (2019). (McLeod et al., 2019)	Matched difference-in-differences; Alberta firms	OHSMS certification associated with lower lost-time injury rates overall, with sector/size variation	Non-random certification and residual confounding; later register and matched evaluations attenuate this estimate and raise selection concerns
China participatory-training trial (I. T. Yu et al., 2017)	Cluster-randomised; 918 intervention workers and two control groups (earlier report: I. Yu et al., 2011)	Compared participatory with didactic training against injury outcomes	Transferability depends on factory context and intervention fidelity
China worker-training RCT (I. Yu et al., 2011)	Randomised trial in 60 factories; 3,479 frontline workers	Assessed injury over one year after participatory/didactic training	Limited ability to infer effects in other sectors
Dyreborg et al. (2022). (Dyreborg et al., 2022)	Systematic review of 100 studies and 120 intervention cases	Stronger support for organisational/group interventions and structural controls	Heterogeneous interventions; many categories not poolable
Abegaz et al. (2025). (Abegaz et al., 2025b)	Cross-sectional; 1,203 workers from 22 Ethiopian construction sites	Climate correlated with safety performance	Self-report and no temporal direction
Brondino et al. (2025). (Brondino et al., 2025)	Two-wave multilevel study; 1,089 workers nested in 143 Italian teams	Examined climate, knowledge, motivation, behaviour and later accidents	Abstract reports mixed support; observational design

The evidence hierarchy is not simply “objective data good, surveys bad”; each design can capture different constructs and bias the exposure–outcome relation differently (Clarke, 2006). Climate surveys capture shared employee perceptions, whereas claims data capture reported injury events; these sources measure different aspects of safety (McLeod et al., 2019; Zohar, 1980). Same-source self-reports may inflate associations, and meta-analytic work shows that measurement contamination and deficiency alter observed climate–injury relationships (Beus et al., 2010). Studies that separately analyse injury reporting, days-away outcomes and claims data further illustrate the distinction among lagging measures (McLeod et al., 2019; Waehrer & Miller, 2009). Griffin and Neal distinguish compliance from participation as separate safety-performance dimensions (Griffin & Neal, 2000). Clarke's meta-analysis found weaker climate-to-accident associations than climate-to-behaviour relationships, particularly when designs were not prospective (Clarke, 2006). Beus and colleagues further showed that injury-to-climate association can be substantial, so reverse causation must be considered (Beus et al., 2010). For OHSMS certification, subsequent evaluations temper the matched Alberta estimate: a Danish register study found adopters already at lower accident risk before certification, with no further reduction at follow-up (Dyreborg et al., 2024); an updated British Columbia analysis reports a diminished effect and suggests earlier findings may reflect the selection of firms into certification (Macpherson et al., 2025); and an Ontario

evaluation finds effects concentrated in larger, recently certified construction firms (Macpherson & McLeod, 2026).

The most credible evaluations combine temporal ordering, comparison groups, worker and management measures, and administrative outcomes. McLeod et al.'s matched longitudinal comparison provides stronger quasi-experimental evidence than cross-sectional correlations (McLeod et al., 2019), although selection into certification may account for part of this association, and subsequent register-based and updated evaluations report mixed and diminishing certification effects (Dyreborg et al., 2024; Macpherson et al., 2025; Macpherson & McLeod, 2026). The participatory training trial, first reported as a conference abstract (Yu et al., 2011) and later detailed as a cluster-randomised comparison (Yu et al., 2017), provides stronger intervention-level inference for specific training approaches. By contrast, the broad intervention review offers a field-level comparison, but its inability to pool many heterogeneous categories means that effects should be understood as context-dependent rather than as a single average treatment effect (Dyreborg et al., 2022). Overall, confidence is moderate that safety practices improve behaviour and climate; it is more conditional for injury reduction, where intervention specificity, time horizon, sector and outcome quality matter.

Research Gaps

1. Causal pathway from system implementation to injuries. Management-system studies often test practice–climate or climate–behaviour relations separately, while large injury studies do not directly measure the hypothesised implementation mechanisms. The certification evidence documents sector and firm-size variation but cannot isolate which system components produced the change (McLeod et al., 2019). The evaluation that was conducted should track system maturity, specific hazard controls, worker perceptions, observed behaviours and injury records together.
2. Small firms and implementation capacity. The Alberta study found that there is no clear injury reduction for small-firm certification; the British Columbia evaluation found reduced effects concentrated in large firms (Macpherson et al., 2025), and the Ontario evaluation found weaker effectiveness in smaller firms (Macpherson & McLeod, 2026), while agriculture studies used small samples (Autenrieth et al., 2015, 2016; McLeod et al., 2019). Studies should test whether consultancy, shared safety personnel, worker representation, or low-cost engineering supports improve fidelity, rather than assuming that a standardised audit transfers equally across firm sizes.
3. Reporting and outcome harmonisation. Safety programs can increase detection and reporting while lowering severe outcomes, as suggested in U.S. establishment-level training research (Waehrer & Miller, 2009). Studies need standard definitions and parallel measurement of near misses, recordables, lost-time injuries, exposure hours, and severity, with explicit time periods.
4. Worker participation and power. Participation is associated with safety performance in Malaysian SMEs and Canadian manufacturing settings, but the available observational evidence does not settle whether participation improves safety, safer organisations enable participation, or both (Geldart et al., 2010; Subramaniam et al., 2016). Research should distinguish consultation from decision authority, examine whether worker recommendations lead to implemented controls, and account for precarious employment and subcontracting.
5. Intervention transfer and long-term effects. Trials of participatory training and manager coaching are promising but concentrated in selected sectors and locations; the Shenzhen participatory-training trial was a cluster randomised trial that measured and reduced injury rates at one-year follow-up (I. Yu et al., 2017; I. T. S. Yu et al., 2011). Whereas the manager-coaching intervention used an AB multiple-baseline design in three wood-processing companies and measured safety compliance and climate rather than injuries (Moon, 2024). The Shenzhen trial counts as a single study, reported in a 2011 conference abstract and described fully in its 2017 paper. The intervention review found variable follow-up and limited pooling across types (Dyreborg et al., 2022). Replication should evaluate long-term injury outcomes and implementation fidelity, particularly where engineering controls and training are combined.
6. Multilevel and reciprocal processes. Longitudinal studies increasingly model teams and supervisors, yet the evidence still includes mixed support for pathways and potential reverse causation from injury

experience to climate (Beus et al., 2010; Brondino et al., 2025; Neal & Griffin, 2006). Future studies should pre-register cross-level hypotheses, measure repeated climate and behaviour, and distinguish within-person change from between-team differences.

CONCLUSION

The evidence supports a clear but conditional conclusion: safety management practices improve safety outcomes when they are enacted as a coordinated system that changes hazards, communicates credible priorities, equips workers to act safely and gives them a meaningful role in identifying and correcting risks. Leadership, training and safety climate are not substitutes for effective hazard control; rather, they help make controls workable and sustained. Behavioural and climate outcomes are more consistently linked to management practices than injuries are, because injuries are rarer, more context-dependent and vulnerable to reporting and reverse-causation effects. The most persuasive evidence comes from interventions that change hazards or work systems with objective injury measures; longitudinal certification comparisons also use objective measures, but pre-certification differences between adopters and non-adopters suggest that selection may explain part of their apparent effects, while the large body of survey research is best read as evidence on plausible mechanisms and associations. Accordingly, organisations should evaluate both leading and lagging indicators and interpret improvement through the lens of implementation quality, workforce participation, sector and firm capacity. The literature does not support a one-size-fits-all claim that formal management systems or training automatically prevent injury; it supports integrated, hazard-specific and learning-oriented safety management, evaluated over time.

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