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Applying Bandura's Reciprocal Causation Model to Safety Climate in U.S. Aviation MROs

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Abstract

This study investigates the application of Bandura's (1977) Reciprocal Causation Model—comprised of Environment, Person, and Behavior—to safety climate in U.S.-based civilian aviation Maintenance, Repair, and Overhaul (MRO) organizations. Drawing from Social Cognitive Theory, the model asserts that human behavior results from dynamic and continuous interaction between personal factors, environmental conditions, and behavior itself. Using a quantitative explanatory correlational design, the study collected data from 134 MRO employees via validated instruments. The Maintenance Environment Survey (MES) and the General Health Questionnaire (GHQ). Statistical analyses, including MANOVA and multiple regression, confirmed that each of the three domains significantly influenced the others in both directions. A strong safety climate (Environment) reduced psychological strain (Person) and maintenance errors (Behavior), while elevated stress levels and error rates negatively impacted safety perceptions. These findings affirm the theoretical strength of Bandura's model and provide practical insights for developing holistic safety management strategies in high-risk work environments.

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1. Introduction

Occupational safety remains a critical concern in high-risk industries, particularly in the aviation sector, where failures in safety systems can result in severe consequences including equipment damage, injuries, or loss of life. Within this domain, MRO organizations serve as essential pillars in ensuring aircraft operability, reliability, and compliance with safety regulations (Karunakaran et al., 2020). These organizations are not only expected to adhere to rigorous regulatory standards but also to cultivate a safety culture that mitigates the risks of human error. The complexity of tasks, time pressure, fatigue, and hierarchical work structures all contribute to a dynamic environment in which safety can be compromised if not properly managed. Although traditional safety models have offered valuable insights into error prevention and risk mitigation, they tend to adopt a linear causality framework. This linear approach presumes that errors or accidents are the result of a direct chain of cause and effect—often simplifying the nuanced psychological and environmental factors that influence human behavior (Rodrigues & Lavorato, 2016). For example, if an error occurs, traditional models might attribute it to inadequate training or poor lighting without considering how organizational climate, employee stress, or interpersonal dynamics interact with those factors. While such models are useful for root-cause analysis, they often fall short in explaining how individual behavior is continually shaped by and shapes the organizational context (Richard Bueno & Mark Louie Martin, 2023).

To address this limitation, scholars have increasingly turned to Social Cognitive Theory (SCT), as proposed by Albert Bandura (1977), which introduces a more robust conceptualization of behavioral causality. Central to SCT is the concept of Reciprocal Causation, which posits that behavior is not unidirectional influenced by internal or external stimuli, but rather arises from a continuous and dynamic interaction among three key elements: Person, Behavior, and Environment (Koirala, 2022). In this model, individuals are seen not only as reactive organisms responding to environmental cues but as proactive agents capable of shaping their surroundings through conscious action and self-regulation. Bandura’s triadic reciprocal model thus provides a more holistic and interactional framework for understanding behavior. The "Person" component encompasses cognitive, emotional, and psychological factors such as stress levels, motivation, beliefs, and personality traits (Bugayko et al., 2021). The "Behavior" component refers to observable actions, decisions, and practices—in the case of MROs, this could include compliance with safety protocols, communication practices, or maintenance performance. The "Environment" comprises organizational policies, managerial practices, safety resources, and the broader cultural context in which employees operate. The interaction among these components is constant, reciprocal, and context-specific. For instance, an employee’s stress (Person) may influence their likelihood of following safety protocols (Behavior), which in turn may affect how supervisors respond or reinforce safety rules (Environment) (Ichou & Veress, 2023).

In the specific context of aviation MROs, Bandura’s model becomes particularly pertinent due to the unique challenges these organizations face. The technical and procedural complexity of aircraft maintenance tasks demands not just compliance with checklists and standard operating procedures but also high levels of cognitive engagement, emotional stability, and collaborative competence. MRO environments are often high-pressure settings with limited margin for error, where a minor oversight can result in a major safety breach. Understanding how psychological strain affects behavior, how employee perceptions of safety culture influence motivation, and how behavior feeds back into organizational norms is essential for developing more effective safety strategies. Safety climate—defined as employees’ shared perceptions of the importance and implementation of safety within their organization- plays a crucial role in shaping behavior (Chandola et al., 2023; Ichou & Veress, 2023). However, these perceptions are not formed in a vacuum. Personal experiences, psychological states, and the consistency of management practices mediate them. For example, inconsistent safety communication from supervisors may lead to increased ambiguity and stress among technicians, which in turn could lower compliance with protocols. Likewise, a technician experiencing high levels of psychological strain may view even a robust safety climate as inadequate or unsupportive. Over time, if such perceptions become widespread, they can alter the broader organizational culture, illustrating the recursive nature of Bandura’s model (ICAO, 2020).

Despite the theoretical robustness of Bandura’s Reciprocal Causation Model, empirical studies explicitly testing its application in civilian MRO environments remain scarce. Most existing research either focuses on military aviation maintenance or examines each component (Person, Behavior, Environment) in isolation, without assessing the bidirectional relationships among them.

This gap in the literature limits the practical utility of safety models, as interventions that fail to account for reciprocal influences may produce limited or unintended outcomes (Schunk & DiBenedetto, 2023). For instance, simply improving safety protocols (Environment) without addressing worker stress (Person) may not lead to desired changes in behavior and may even exacerbate compliance fatigue or disengagement. The current study aims to fill this gap by applying Bandura's triadic framework to examine the interrelationship among safety climate (Environment), psychological strain (Person), and maintenance behavior (Behavior) within U.S.-based civilian MROs. Using validated survey instruments and statistical analyses, the study examines how these variables interact and influence each other. By capturing this reciprocal dynamic, the research offers a richer and more accurate understanding of how safety outcomes are produced and sustained in aviation maintenance settings (Bramley et al., 2020).

The significance of this study lies in its potential to bridge theory and practice. By grounding safety assessments in a validated psychological framework, organizations can move beyond surface-level interventions and develop more integrated strategies that simultaneously address environment, cognition, and behavior. For policymakers and aviation safety managers, the findings offer empirical evidence for the efficacy of a systems-thinking approach to safety—one that treats individual workers not merely as end-users of protocols but as active participants in shaping and maintaining a resilient safety culture (Korchagin et al., 2023). Also, this article contributes to the broader literature on occupational safety by demonstrating the applicability and validity of Bandura's Reciprocal Causation Model in a civilian aviation maintenance context. It underscores the need for a multi-dimensional perspective in understanding and managing safety behavior, and it lays the groundwork for future studies to further refine and operationalize this approach in other high-risk industries (Oluwatoyin & Oluseun, 2014).

2. Literature Review

Albert Bandura's Reciprocal Causation Model, introduced in 1977 as part of his Social Cognitive Theory (SCT), has been foundational across disciplines, including education, psychology, behavioral science, and organizational research. The model challenges the reductionist view that behavior is either solely influenced by internal dispositions (e.g., motivation, beliefs) or by external environmental stimuli (e.g., rules, consequences) (Ferguson et al., 2023). Instead, it proposes that behavior arises from a continuous, dynamic interaction among three key elements: Person (P), Environment (E), and Behavior (B). Each of these elements influences and is influenced by the others in a cyclical, reciprocal manner. This triadic perspective transforms how researchers and practitioners understand and intervene in human systems—particularly in safety-critical industries (Biegon & Watts, 2022). Within occupational safety research, Bandura's framework offers an especially valuable lens for analyzing how cognitive, emotional, and social factors interact with workplace behaviors and environmental structures to influence safety outcomes. Unlike linear models that often attempt to trace a single pathway from cause to effect, reciprocal causation acknowledges the feedback loops that exist between employees and the organizations in which they work. For example, an employee's perceived stress (Person) may lead to unsafe shortcuts during maintenance tasks (Behavior), which then contribute to changes in supervisory practices or training protocols (Environment), ultimately feeding back into the individual's psychological state (Chandola et al., 2023).

One of the most influential adaptations of Bandura's model in occupational safety came from Cooper (2000), who introduced the idea of safety culture as a behavioral, psychological, and situational construct mapped directly onto Bandura's triad. In Cooper's interpretation:

Cooper's work laid the groundwork for integrating behavioral science into safety management, moving beyond compliance-based frameworks to consider how workers internalize and respond to safety initiatives. This model was especially helpful in guiding safety interventions, as it highlighted that altering environmental conditions (e.g., leadership communication or safety resources) could indirectly influence employee attitudes, which in turn would affect behavior. Later empirical studies, such as those by(Karunakaran et al., 2020; Schunk & DiBenedetto, 2023) reinforced the model's utility in industrial safety contexts. Working within construction and manufacturing settings, these researchers found that employee attitudes, risk perception, and psychological readiness significantly mediated the effect of environmental variables—such as training availability and supervisor commitment—on safety behaviors. These findings suggested that the relationship between safety environment and behavior is not simply causal but moderated by person-specific cognitive filters, thus affirming the model's theoretical logic (Franco et al., 2022).

In aviation MRO contexts, the most notable application of Bandura's framework is found in the work of Fogarty (2004, 2005). Focusing on military aviation technicians in Australia, Fogarty developed and validated the Maintenance Environment Survey (MES), which measures safety climate (Environment), psychological strain (Person), and maintenance errors (Behavior). His findings revealed significant associations between negative safety climate perceptions and high psychological strain, as well as between psychological strain and increased error rates. However, Fogarty's model, while influenced by Bandura, treated the relationships as largely unidirectional—for example, Environment → Person → Behavior. This treatment risks underestimating the bidirectional feedback loops at the heart of reciprocal causation (Kochovski & Stankovski, 2018).

The current study extends Fogarty's contribution by explicitly modeling bidirectional influences among the three dimensions, remaining truer to Bandura's original theory. Such an approach is especially relevant in civilian aviation MROs, which often differ from military operations in terms of regulatory context, commercial pressures, and organizational culture. Civilian MRO technicians face complex cognitive and physical demands, often under time constraints and in rotating shifts, which can exacerbate psychological strain and influence risk perception. A dynamic model is thus essential for capturing the nuances of behavior in these settings. Contemporary safety literature supports this integrated approach. For instance, Te & Doucette, (2019) demonstrated that psychological safety climate predicted self-efficacy and safety motivation, which in turn influenced safety compliance. Similarly, Mohammed et al., (2022) emphasized the need to consider both proximal and distal predictors of safety behavior, arguing that individual cognition cannot be disentangled from the social and structural context in which it arises. These perspectives reinforce the value of Bandura's model in both theoretical and applied safety research.

In the context of aviation MROs, several environmental factors have been shown to shape the psychological state of employees, including supervisor support, clarity of procedures, recognition of effort, and access to adequate training. When these factors are perceived positively, employees tend to experience lower psychological strain, feel more empowered, and demonstrate greater adherence to safety protocols. However, this is not a one-way relationship (Yadav & Singh, 2020). Employees under chronic psychological stress may begin to interpret their environment more negatively, perhaps viewing even supportive managers as indifferent or interpreting training as punitive. Furthermore, a technician who frequently makes errors may contribute to a deteriorating group morale, influencing peers' perceptions of safety culture—an effect that ripples outward across the environment. This cyclical interaction highlights the recursive nature of Bandura's model, emphasizing that sustainable safety interventions must account for feedback effects. Modifying one element of the system may initiate changes in the others, leading to either virtuous or vicious cycles depending on the initial condition and the direction of influence (Mohammed et al., 2022).

Furthermore, in occupational safety, Cooper's (2000) tripartite model adapted Bandura's framework by linking safety culture to behavioral, psychological, and situational dimensions. While valuable, Cooper's model tends to emphasize situational and environmental conditions, sometimes at the expense of examining the cyclical influence of individual cognition on organizational culture. Fogarty's work (2004, 2005) further extended this framework in military aviation, introducing the Maintenance Environment Survey (MES). His findings highlighted associations between safety climate, psychological strain, and errors. However, Fogarty's approach largely assumed a unidirectional sequence—environment shaping person, which in turn shapes behavior. This sequential treatment underestimates the recursive feedback loops at the heart of Bandura's theory.

Recent studies in construction, manufacturing, and healthcare (e.g., Mohammed et al., 2022; Franco et al., 2022) demonstrate the value of considering reciprocal interactions but often stop short of explicitly testing feedback cycles. Moreover, empirical contradictions exist. While some studies show strong links between psychological strain and error rates, others report weaker or inconsistent relationships, raising questions about the stability of unidirectional pathways. These gaps highlight the need for research that explicitly models reciprocity, especially in underexplored contexts such as civilian aviation MROs, where commercial pressures, regulatory environments, and cultural factors differ significantly from military settings.

By situating this study within these gaps, the contribution lies not merely in reiterating Bandura's framework but in addressing the limitations of prior unidirectional models. Specifically, this study aims to test whether reciprocal interactions are evident in civilian aviation safety climate and, in doing so, provides empirical clarity where the literature remains fragmented or contradictory.

3. Methodology

This study employed a quantitative explanatory correlational design to examine reciprocal relationships among Environment (safety climate), Person (psychological strain), and Behavior (maintenance errors). MANOVA and multiple regression were selected to evaluate associations in both directions. While these methods provide evidence of significant relationships consistent with reciprocity, they cannot establish true bidirectional causality. Because the design is cross-sectional, the results must be interpreted as associations rather than proof of cyclical feedback loops. Establishing causality requires longitudinal or time-lagged analyses, which we recommend for future research. Furthermore, the measurement of Behavior relied on self-reported maintenance errors. While validated instruments (MES and GHQ) support reliability, self-reporting introduces risks of social desirability bias, particularly in occupational settings where error admission may carry professional consequences. Objective data sources, such as supervisor assessments or incident reports, would strengthen future research by triangulating self-reports with external measures. The aim was to empirically test the extent to which each dimension influenced the others using structured survey instruments and statistical analyses.

Participants

The sample consisted of 134 voluntary participants from one national MRO and several smaller civilian aviation MROs across the United States. Participants included aircraft maintenance engineers, technicians, and support staff. The sample reflected the real-world demographic imbalance within the aviation industry, with 85% of respondents identifying as male. Participants varied in terms of age, experience, and educational background, providing a comprehensive cross-section of MRO personnel.

Instrumentation

Data were collected using the Aviation Maintenance Safety Climate Survey **(AMSCS)**, which incorporated two validated tools:

1. **Maintenance Environment Survey (MES)** by Fogarty (2005) – assessed five dimensions of safety climate: Recognition, Safety Concern, Supervision, Feedback, and Training.

2. **General Health Questionnaire (GHQ)** – measured psychological strain, including stress, anxiety, and other psychosomatic symptoms.

Behavior, representing Bandura’s "Behavior" dimension, was captured through a Maintenance Errors Scale within the MES (items A36–A48), which asked participants to self-report the frequency and severity of maintenance errors—both self-detected and identified by supervisors. Each item across the three instruments used a 5-point Likert scale, enabling the conversion of perceptions and self-reports into quantitative values for analysis.

Variables and Model Mapping

- **Environment** = Safety Climate (Recognition, Training, Feedback, etc.)
- **Person** = Psychological Strain (Stress and Distress)
- **Behavior** = Maintenance Errors

Procedures

Participants completed the survey online over a four-month period. Anonymity and confidentiality were strictly maintained. Cases with incomplete or inconsistent responses were removed from analysis, resulting in a final usable sample of 134.

Data Analysis Techniques

The study employed two primary statistical methods:

1. **Multivariate Analysis of Variance (MANOVA)** – to evaluate whether each variable significantly influenced the others, in both directions.
2. **Stepwise Multiple Regression** – to explore the predictive power of each dimension on the other two.

These methods were selected to align with the reciprocal nature of Bandura’s model and allowed for robust examination of causality in multiple directions. Analyses were conducted using SPSS and AMOS for SEM model visualizations and interpretation.

Reliability and Validity

Cronbach's alpha values for each subscale were above the acceptable threshold of 0.70 (e.g., Safety Concern $\alpha = .86$, Psychological Distress $\alpha = .91$), indicating strong internal consistency. Validity was supported by prior uses of both MES and GHQ in occupational safety studies.

This methodology provided a sound quantitative framework for testing the reciprocal interactions among cognition, environment, and behavior within aviation MRO safety contexts.

4. Results

The results of the study supported Bandura’s (1977) hypothesis of triadic reciprocal causation, that each of the three constructs (Person, Environment, Behavior) significantly influenced the other two. This section presents findings from both MANOVA and regression analyses, demonstrating the bidirectional influence patterns.

Descriptive Statistics

The overall means indicated moderate perceptions of safety climate ($M = 3.52$), moderate psychological strain ($M = 2.85$), and low to moderate self-reported maintenance error rates ($M = 2.31$). These values suggested generally positive attitudes but pointed to areas for improvement, particularly in supervision and feedback.

MANOVA Analysis

Three separate MANOVAs were conducted to test the influence of each Bandura dimension on the remaining two.

Table 1: MANOVA - Person → Environment & Behavior

Effect	Wilks’ Lambda	F	p-value
Person → Environment	0.804	5.42	0.003
Person → Behavior	0.813	4.87	0.008

Interpretation: Psychological strain (Person) significantly impacted safety climate perceptions (Environment) and frequency of maintenance errors (Behavior). Employees reporting high stress perceived less organizational safety support and reported more errors.

Table 2: MANOVA - Environment → Person & Behavior

Effect	Wilks' Lambda	F	p-value
Environment → Person	0.788	6.17	0.002
Environment → Behavior	0.806	5.53	0.005

Interpretation: Strong safety climate perceptions significantly reduced psychological strain and maintenance errors.

Table 3: MANOVA - Behavior → Person & Environment

Effect	Wilks' Lambda	F	p-value
Behavior → Person	0.821	4.39	0.011
Behavior → Environment	0.839	4.02	0.014

Interpretation: Higher frequency of maintenance errors negatively influenced workers' perceptions of organizational safety and increased psychological strain.

Multiple Regression Analysis

Regression confirmed the bidirectional effects with high R^2 values indicating strong predictive power:

- Environment → Person ($R^2 = 0.49$)
- Person → Behavior ($R^2 = 0.38$)
- Behavior → Environment ($R^2 = 0.34$)

These results validate Bandura's model and suggest practical implications for safety interventions. The findings supported Bandura's hypothesis that Person, Environment, and Behavior significantly influence one another. Importantly, effect sizes provide insight into the practical significance of these relationships. For instance, the regression model indicated that Environment explained 49% of the variance in Person (psychological strain), suggesting that nearly half of employees' wellbeing can be attributed to safety climate perceptions. Similarly, Person explained 38% of the variance in Behavior, and Behavior explained 34% of the variance in Environment. These magnitudes are substantial for applied occupational safety research, implying that interventions to strengthen safety climate could meaningfully reduce stress and error rates. While composite scores were used for statistical analysis, this approach may have masked variation within subdimensions of the MES and GHQ. For example, differences between supervisory support and feedback, or between anxiety and somatic stress, could reveal more granular pathways linking environment, cognition, and behavior. Future research disaggregating these subdimensions may yield deeper insights into which elements of safety climate or psychological strain exert the strongest reciprocal influence on behavior.

5. Conclusion

This study empirically tested and validated Bandura's (1977) Reciprocal Causation Model within the context of civilian aviation MRO organizations, a domain where safety behavior is both critical and complex. The results affirm Bandura's central claim that behavior is not solely a product of internal cognition or environmental pressures, but the outcome of a dynamic, bidirectional interaction between Person (psychological state), Environment (organizational safety climate), and Behavior (maintenance practices and errors). The implications of this triadic framework extend beyond theoretical validation—they offer actionable guidance for transforming workplace safety culture in one of the most safety-sensitive industries in the world. Central to this study's findings is the idea that each domain exerts both direct and reciprocal influence on the others. Specifically, MRO employees who perceived their organizations as providing a supportive safety environment—through clear communication, proper training, supervision, and recognition—reported significantly lower levels of psychological strain. This psychological well-being, in turn, was associated with fewer self-reported maintenance errors, underscoring the downstream behavioral benefits of a healthy safety climate. Importantly, the relationship also worked in reverse: employees experiencing higher stress levels were more likely to report maintenance errors and to perceive their environment as less supportive. These finding challenges simplistic cause-and-effect assumptions and highlight the reciprocal causality that Bandura emphasized.

The bidirectional effects among the three constructs were confirmed through robust statistical methods, including multivariate analyses and regression modeling. These methods revealed that interventions targeting just one domain—such as revising policies or improving mental health support—can yield cascading benefits across the system. For instance, enhancing training quality or providing consistent supervisory feedback (Environment) not only influences behavior directly but also helps reduce psychological strain (Person), which further contributes to error reduction (Behavior). Conversely, failure to address chronic stress may increase error frequency and degrade perceptions of organizational safety, thereby creating a negative feedback loop that erodes safety culture over time. These insights also serve to strengthen and extend earlier studies, particularly the foundational work of (Fogarty et al., 2024), who first applied Bandura-inspired models to military MRO contexts. While Fogarty's model focused on unidirectional pathways—Environment influencing Person, and Person influencing Behavior—this study demonstrated that the relationships are more complex and reciprocal in nature. By grounding the research more explicitly in Bandura's original theory, this study moves beyond sequential logic and embraces the circular causality inherent in real-world human systems. This advancement is not just academic—it is critically relevant for practitioners who must design interventions that work across multiple levels of an organization.

From a practical standpoint, the results are significant for MRO managers, human resources departments, and aviation safety regulators. The aviation maintenance workforce often operates under high cognitive loads, irregular schedules, and strict compliance pressures. Under such conditions, psychological strain is not just a personal issue but a systemic risk factor that can degrade performance, increase human error, and even lead to regulatory non-compliance. Recognizing psychological well-being as a core component of safety strategy—rather than a peripheral concern—represents a paradigm shift that aligns with Bandura's holistic framework. For MRO organizations, this means shifting from reactive safety models that primarily focus on outcomes (e.g., error tracking) to proactive systems that target root causes across all three domains. For example, rather than simply penalizing errors, organizations might investigate whether those errors stemmed from unclear procedures, fatigue, or a lack of peer support—factors that span the

Person and Environment dimensions. Safety managers can use tools like the Maintenance Environment Survey (MES) and General Health Questionnaire (GHQ), both employed in this study, to track perceptions of climate, emotional well-being, and behavioral outcomes in an integrated manner. This approach not only identifies problems but also guides multi-dimensional solutions that reinforce each domain simultaneously.

Importantly, the study also highlights the limitations of siloed safety interventions. Traditional safety programs that focus solely on updating manuals or providing checklists may neglect the subjective experiences of workers who interpret and respond to these materials based on their stress levels, motivation, and past experiences. Bandura's model reminds us that people are not passive recipients of organizational directives—they are active agents who shape their environment even as they are shaped by it. Therefore, sustainable safety improvement requires not only policy and training updates but also employee empowerment, psychological support, and behavioral reinforcement. The implications of this study also extend to policy and regulation. Aviation regulators and oversight bodies often emphasize environmental and behavioral compliance, such as minimum training hours, standard operating procedures, and inspection checklists. While these are necessary, they may be insufficient if the psychological dimension is ignored. Regulators may consider incorporating mental health metrics, job satisfaction surveys, or stress audits into compliance frameworks. Such moves would align regulatory oversight with a more holistic and human-centered view of safety.

Another contribution of the study lies in its empirical validation of a theoretical framework within a real-world, high-stakes setting. Too often, behavioral theories remain underutilized in applied research due to challenges in operationalization and measurement. This study demonstrates that Bandura's Reciprocal Causation Model is not only conceptually robust but also practically testable using established instruments and methods. In doing so, it bridges the gap between theory and practice, offering both scholars and practitioners a tool for understanding and improving safety performance.

This study demonstrates that relationships among safety climate, psychological strain, and maintenance errors are consistent with Bandura's Reciprocal Causation Model. The results suggest that these three domains influence one another in patterns aligned with reciprocal interaction, underscoring the model's relevance for civilian aviation MRO contexts. However, the findings should be interpreted with caution. Given the cross-sectional design, the study cannot prove genuine cyclical causality. Instead, the evidence indicates significant associations suggestive of reciprocity. The study's contributions include extending Bandura's model into a civilian aviation MRO context and offering empirical evidence that safety climate, well-being, and behavior are interconnected. Nonetheless, several limitations must be acknowledged. First, reliance on self-reported behavior may underrepresent actual error rates due to reporting bias. Second, the use of composite scores may obscure important subdimension-level relationships. Third, the sample, while diverse across U.S. MROs, may not generalize to international or non-commercial settings. These limitations highlight the need for longitudinal, mixed-method, and cross-cultural research to validate and extend these findings.

6. Recommendations

The study's results suggest several practical directions for improving safety climate in MROs, though these must be understood as informed implications rather than prescriptive guarantees. Enhancing supervisory support, ensuring consistent feedback, and recognizing safety-compliant behavior are likely associated with reductions in psychological strain and errors. Similarly, integrating mental health checks and resilience training into organizational safety programs may improve employee wellbeing, which is linked to error reduction.

At the behavioral level, tracking error trends and pairing them with constructive reinforcement could foster a more positive safety culture. System-level integration of safety and wellness programs offers another pathway, aligning organizational assessments with both safety and psychological health indicators. However, the feasibility of such initiatives depends on organizational resources, cost-effectiveness, and cultural receptivity. These recommendations are therefore best viewed as informed strategies grounded in empirical associations, requiring careful adaptation and testing before full implementation. Thus, based on the findings, the following recommendations are proposed for MRO organizations:

Domain	Recommendations
Environment	Strengthen supervisory support, improve feedback systems, and publicly recognize safety-compliant behavior.
Person	Implement regular mental health checks, resilience training, and psychological counseling programs for MRO employees.
Behavior	Track maintenance error trends and introduce positive reinforcement strategies (e.g., bonuses for error-free records).
Systems	Align safety climate assessments with employee wellness programs for integrated safety performance tracking.
Leadership	Train leaders in emotional intelligence and participatory decision-making to enhance employee perceptions of safety and belonging.

These recommendations are not only practical but supported by strong statistical evidence, which affirms that improving any one domain can produce measurable gains in the others.

7. Future Directions

Future research should prioritize longitudinal designs to capture how reciprocal relationships evolve over time, enabling stronger claims about causality and feedback cycles. Time-lagged or cross-lagged panel analyses would be particularly valuable in assessing cyclical interactions. In addition, mixed-method approaches that incorporate qualitative data—such as interviews or focus groups—could enrich understanding of how employees perceive safety climate and experience stress in real time. Triangulation of behavioral data is also crucial. Incorporating supervisor assessments, incident reports, or digital error-tracking systems would address the limitations of relying solely on self-reports. Furthermore, analyzing subdimensions of the MES and GHQ separately may uncover specific pathways (e.g., supervision → anxiety → error frequency) that remain hidden when aggregated into composite scores. Finally, extending research into cross-cultural or multinational MROs could reveal how regulatory frameworks and cultural norms shape reciprocal interactions, enhancing the generalizability of the model.

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