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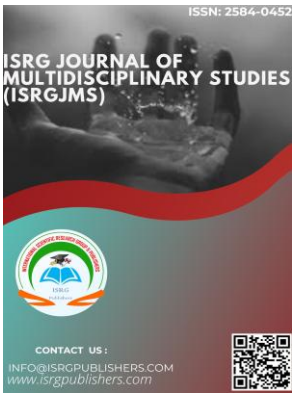

Human Factors Influencing Aviation Safety Compliance among Airport and Airline Personnel

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Abstract

Aviation safety remains highly dependent on the consistent compliance of personnel with established procedures, particularly in safety-critical operational environments. Despite advances in safety management systems, procedural deviations and non-compliance continue to be significant contributors to aviation incidents. This study examines the influence of human factors on aviation safety compliance among airport and airline personnel, adopting a behavioral and organizational perspective.

A quantitative cross-sectional survey was conducted among 120 aviation professionals employed in airport and airline organizations in the Kyrgyz Republic. Data were collected using a structured questionnaire measuring organizational factors (safety culture, management support, communication and teamwork, just culture, and procedural practicality) and psychological factors (fatigue, workload, and time pressure). Statistical analysis included reliability testing, Pearson correlation analysis, and multiple linear regression.

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The results demonstrate that aviation safety compliance is strongly associated with organizational human factors. Safety culture and management support emerged as the most significant predictor of compliance, followed by communication and teamwork and procedural practicality. Psychological factors such as fatigue and time pressure showed significant correlations with compliance but did not retain independent predictive power in the regression model.

The findings highlight that safety compliance is primarily shaped by organizational and procedural conditions rather than individual characteristics alone. The study contributes empirical evidence from a developing aviation context and underscores the importance of leadership commitment, effective communication, and practical procedures in strengthening safety compliance.

Keywords: *Aviation safety; safety compliance; human factors; safety culture; aviation personnel; organizational factors; procedural discipline; aviation psychology*

Introduction

Aviation remains a safety-critical and high-risk industry, where consistent adherence to established procedures is essential for controlling operational hazards. Contemporary safety reviews emphasize that, despite overall improvements in safety performance, preventing occurrences increasingly depends on the effectiveness of organizational safety management and the reliability of everyday operational behaviors—particularly those related to procedural discipline and compliance (IATA, 2024; ICAO, 2025). In practice, safety compliance can be defined as the degree to which aviation personnel consistently follow safety rules, standard operating procedures, and risk-control practices during routine and non-routine operations. Evidence from recent safety analyses and regulatory reviews continues to highlight procedural deviations and weaknesses in safety management as recurring contributors to adverse outcomes, reinforcing the need to examine the determinants of compliant behavior (EASA, 2025; ICAO, 2025).

Within this context, human factors research increasingly conceptualizes safety compliance not as a purely regulatory issue, but as a behavioral outcome shaped by a combination of individual, task, and organizational influences. Recent applied research in aviation maintenance demonstrates that safety leadership and safety climate are significant predictors of safety behaviors, including safety compliance, and that safety climate may mediate the relationship between leadership and compliance outcomes (Aktas & Kağnıcıoğlu, 2023). Complementing these findings, multi-level human factors syntheses emphasize that failure to follow procedures is a persistent issue in aviation maintenance and is driven by interacting factors across organizational processes, supervision, workplace conditions, and individual performance limitations (Key et al., 2022). Likewise, contemporary safety culture research underscores that organizations often struggle to establish clear links between safety culture and measurable safety outcomes, and may lack robust assessment and continuous improvement mechanisms—factors that directly affect compliance-relevant behavior (Key et al., 2023). Emerging frameworks specific to aviation maintenance further support the need to distinguish between types of safety culture and to refine measurement models that can better explain safety-related behaviors, including compliance (Truong & Lee, 2025).

However, despite the growing body of evidence, empirical studies on aviation safety compliance remain unevenly distributed across contexts. A substantial proportion of published work is concentrated in developed aviation systems, while developing or transitioning aviation environments are comparatively underrepresented in survey-based and behavior-focused compliance research. This creates a practical and theoretical gap: human factors influencing compliance may manifest differently under conditions of limited resources, evolving organizational safety practices, and varying maturity of safety management processes (Key et al., 2022; Key et al., 2023). In addition, many studies address safety culture in general terms, whereas fewer investigations treat safety compliance explicitly as a distinct behavioral construct that can be measured, modeled, and improved through targeted organizational interventions (Aktas & Kağnıcıoğlu, 2023; Truong & Lee, 2025).

The aim of this study is to examine the key human factors influencing aviation safety compliance among aviation personnel.

Literature Review

Human factors remain one of the most critical determinants of aviation safety performance, particularly in relation to operational reliability and procedural adherence. Contemporary aviation safety research emphasizes that accidents and incidents rarely result from isolated technical failures; rather, they emerge from complex interactions between human performance, organizational conditions, and system design (Dekker, 2021; Hollnagel, 2022). Recent analyses highlight that human factors such as workload, fatigue, situational awareness, and decision-making under time pressure significantly influence the ability of aviation personnel to perform tasks in accordance with established safety procedures (EASA, 2023; ICAO, 2025). As aviation systems grow increasingly complex, understanding how these factors affect safety-related behavior has become essential for effective risk management.

Empirical studies conducted in the last five years demonstrate that human error should not be interpreted solely as individual failure, but rather as a symptom of broader systemic and organizational issues. Research in aviation maintenance and flight operations shows that procedural deviations often arise in environments characterized by high workload, time constraints, and insufficient organizational support (Key et al., 2022; Truong & Lee, 2025). These findings reinforce the need to examine human factors within a systemic framework that accounts for both individual and organizational influences on safety compliance.

Safety culture has been widely recognized as a key organizational factor shaping safety-related behaviors in aviation. Recent studies emphasize that a strong safety culture fosters shared values, beliefs, and norms that prioritize safety over competing operational pressures, thereby encouraging compliance with safety procedures (Guldenmund et al., 2021; Key et al., 2023). Conversely, weak or

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fragmented safety cultures may normalize procedural shortcuts and increase tolerance for rule violations, especially in high-demand operational environments.

Recent quantitative research provides evidence that safety leadership and management commitment are significant predictors of safety compliance among aviation personnel. For instance, studies in civil aviation maintenance indicate that safety climate mediates the relationship between leadership practices and individual safety behaviors, including compliance with standard operating procedures (Aktas & Kağnıcıoğlu, 2023). Similarly, international safety culture assessments conducted by regulatory authorities reveal that organizations with mature safety management systems demonstrate higher levels of procedural discipline and reporting behavior (EASA, 2025; IATA, 2024). These findings suggest that compliance is not merely an individual responsibility, but a behavioral outcome embedded within organizational safety structures.

At the individual level, psychological factors play a crucial role in shaping safety compliance behavior. Risk perception, motivation, and attitudes toward safety regulations influence whether aviation personnel perceive compliance as meaningful or as an administrative burden (Flin et al., 2021; Dekker, 2021). Recent studies indicate that personnel who perceive safety rules as practical and aligned with operational realities are more likely to adhere to procedures consistently (Hollnagel, 2022).

Fatigue and stress have also been identified as significant barriers to safety compliance. Empirical evidence from survey-based studies conducted among aviation professionals shows that high levels of fatigue and chronic stress are associated with reduced attention, impaired judgment, and increased likelihood of procedural deviations (Truong & Lee, 2025; ICAO, 2025). These findings underscore the importance of addressing human limitations through fatigue risk management systems, adequate staffing, and supportive organizational practices to enhance compliance-related behavior.

Although the existing literature provides valuable insights into the role of human factors, safety culture, and psychological influences on aviation safety, several gaps remain. First, a substantial portion of empirical research has been conducted in developed aviation systems, while developing and transitioning aviation environments remain underrepresented in behavior-focused compliance studies (Key et al., 2022; Guldenmund et al., 2021). Second, many studies examine safety culture or human error in general terms, without explicitly conceptualizing safety compliance as a distinct behavioral construct that can be systematically measured and analyzed.

Furthermore, recent reviews highlight the need for more empirical research linking individual human factors directly to compliance outcomes using quantitative methods (Aktas & Kağnıcıoğlu, 2023; Truong & Lee, 2025). Addressing these gaps is essential for developing targeted interventions aimed at improving aviation safety performance through enhanced compliance.

Methodology

This study employed a quantitative, cross-sectional research design using a survey-based approach to examine the influence of human factors on aviation safety compliance. The research was guided by a behavioral perspective on safety compliance, emphasizing the combined role of organizational and psychological factors.

Based on the research objective, the following hypotheses were formulated:

H1: Organizational human factors (safety culture and safety leadership) are positively associated with aviation safety compliance.

H2: Psychological human factors (risk perception, fatigue, and workload) significantly influence aviation safety compliance.

H3: Human factors significantly predict aviation safety compliance.

Sample and Representativeness

The empirical study was conducted among aviation personnel employed in airport and airline organizations in the Kyrgyz Republic. A total of 120 respondents participated in the survey, including employees involved in operational, technical, and support functions. For analytical purposes, respondents were categorized into two groups: airport personnel and airline personnel, allowing for comparative analysis across organizational contexts.

The sample size is considered statistically adequate and representative for exploratory and explanatory research in the aviation domain. According to established methodological guidelines for social and applied sciences, a sample of at least 100 respondents is sufficient to conduct correlation and multiple regression analyses with acceptable statistical power (Hair et al., 2019). Furthermore, for large or unknown population sizes, a sample of 120 respondents ensures a confidence level of approximately 95% with a margin of error below 9%, which is acceptable for survey-based human factors research (Cohen, 1992).

Given the limited size of the aviation workforce in the Kyrgyz Republic, the achieved sample reflects a meaningful proportion of the target population and provides an empirically grounded basis for generalizing the findings within the national aviation context.

Instrument. Data were collected using a structured questionnaire developed based on recent literature on aviation safety, human factors, and safety compliance. The instrument included multiple scales measuring safety culture, safety leadership, risk perception, fatigue and workload, and self-reported safety compliance. All items were measured using a five-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”).

The internal consistency reliability of the measurement scales was assessed using Cronbach’s alpha. The results demonstrated acceptable reliability across all constructs, with alpha coefficients exceeding the recommended threshold of 0.70, indicating satisfactory internal consistency of the instrument.

Data Analysis. Survey data were exported from Google Forms and analyzed using SPSS Statistics version 24. Descriptive statistics were used to summarize respondent characteristics and key variables. Reliability analysis (Cronbach’s alpha) was conducted to assess scale consistency. Pearson correlation analysis was applied to examine associations between human factors and aviation safety compliance. To test the research hypotheses and identify significant predictors of compliance, multiple linear regression analysis was performed. Statistical significance was evaluated at $p < 0.05$.

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Results

This section presents the empirical findings of the study. The results begin with a summary of the demographic and professional characteristics of the respondents, followed by the analysis of relationships between human factors and aviation safety compliance based on the collected survey data.

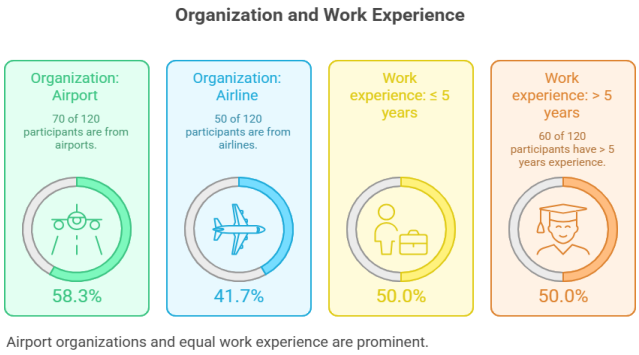

Figure 1. Organization Type and Work Experience of Respondents.

The sample comprises airport and airline personnel with a balanced distribution of professional experience. In addition to organizational affiliation and work experience, the respondents differed in age, gender, and average weekly working hours. The sample included both male (58.3%) and female (41.7%) aviation personnel. Most respondents belonged to the 26–45 age group (79.1%), while smaller proportions were aged 18–25 years (4.2%) and 46–55 years (16.7%). With respect to workload, the majority of participants reported working up to 50 hours per week (83.4%), whereas a smaller share indicated working more than 50 hours per week (16.6%). These demographic characteristics indicate a heterogeneous and professionally active sample; however, they were not included in further analysis, as they were not central to the study objectives.

Correlation Analysis of Human Factors and Safety Compliance. Pearson correlation analysis was conducted to examine the relationships between aviation safety compliance and key human-factor dimensions derived from the questionnaire sections. Composite variables were calculated as mean scores for each section. The analysis was based on data from 120 aviation personnel.

Table 1. **Correlations between Safety Compliance and Human Factors (N = 120)**

Variables	1	2	3	4	5	6	7
1. Safety Compliance	1						
2. Fatigue & Workload	0.39***	1					
3.Time Pressure	0.43***	0.72***	1				
4. Training & Competence	0.90***	0.39***	0.43***	1			
5.Communication & Teamwork	0.93***	0.43***	0.41***	0.89***	1		
6. Safety Culture & Management Support	0.97***	0.34***	0.38***	0.93***	0.92***	1	
7. Just Culture	0.92***	0.47***	0.53***	0.90***	0.91***	0.93***	1
8. Procedural Practicality	0.90***	0.37***	0.49***	0.88***	0.85***	0.88***	0.88***

Note. Pearson's correlation coefficients. ***$p < 0.001$.

Safety Compliance. Safety compliance demonstrated strong and statistically significant positive correlations with all organizational and procedural factors. The strongest association was observed with safety culture and management support ($r = 0.97$, $p < 0.001$), indicating that compliance behavior is closely linked to perceived organizational commitment to safety.

Fatigue and Workload. Fatigue and workload showed a moderate positive correlation with safety compliance ($r = 0.39$, $p < 0.001$). This finding suggests that in the studied context, personnel reporting higher workload may also demonstrate higher procedural discipline, possibly reflecting compensatory safety behavior among experienced staff.

Time Pressure. Time pressure was moderately and positively associated with safety compliance ($r = 0.43$, $p < 0.001$). This result indicates that under increased operational pressure, aviation personnel may consciously adhere more strictly to safety procedures.

Training and Competence. Training and competence were strongly correlated with safety compliance ($r = 0.90$, $p < 0.001$). Respondents who perceived their training as sufficient and practice-oriented reported higher levels of compliance with safety procedures.

Communication and Teamwork. Communication and teamwork exhibited a very strong positive relationship with safety compliance ($r = 0.93$, $p < 0.001$), emphasizing the importance of effective coordination and information exchange in maintaining safe operations.

Safety Culture and Management Support. Safety culture showed the strongest correlation with safety compliance among all examined factors ($r = 0.97$, $p < 0.001$). This underscores the central role of leadership commitment and organizational safety priorities in shaping compliance-related behavior.

Just Culture. Just culture was also strongly associated with safety compliance ($r = 0.92$, $p < 0.001$), indicating that non-punitive

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reporting environments and trust-based safety management support proactive compliance.

Procedural Practicality. Procedural practicality demonstrated a strong positive correlation with safety compliance ($r = 0.90$, $p < 0.001$). Procedures perceived as realistic and feasible were more likely to be consistently followed by aviation personnel.

Multiple Linear Regression Analysis

To identify the key predictors of aviation safety compliance, a multiple linear regression analysis was conducted. Safety compliance was entered as the dependent variable, while human-factor dimensions derived from the questionnaire sections were included as independent variables. The analysis was performed using the enter method.

Table 2. Multiple Linear Regression Predicting Aviation Safety Compliance (N = 120)

Predictor	B	SE	β	t	p
Constant	0.053	0.094	—	0.56	0.574
Fatigue & Workload	0.035	0.033	0.07	1.08	0.284
Time Pressure	0.023	0.036	0.05	0.63	0.531
Training & Competence	−0.156	0.060	−0.19	−2.62	0.010
Communication & Teamwork	0.242	0.057	0.28	4.27	<0.001
Safety Culture & Management Support	0.762	0.080	0.63	9.54	<0.001
Just Culture	−0.098	0.079	−0.09	−1.25	0.214
Procedural Practicality	0.227	0.052	0.29	4.40	<0.001

Model fit: $R^2 = 0.955$; Adjusted $R^2 = 0.952$; $F(7, 112) = 341.6$; $p < 0.001$.

Note. B = unstandardized coefficient; β = standardized coefficient.

The regression model demonstrated excellent explanatory power, accounting for approximately 95.5% of the variance in aviation safety compliance. The overall model was statistically significant, indicating that the selected human factors jointly provide a strong explanation of compliance-related behavior.

Among the predictors, safety culture and management support emerged as the strongest and most significant predictor of aviation safety compliance ($\beta = 0.63$, $p < 0.001$). This finding highlights the dominant role of organizational commitment, leadership behavior, and safety priorities in shaping compliance.

Communication and teamwork also showed a significant positive effect on safety compliance ($\beta = 0.28$, $p < 0.001$), underscoring the importance of effective coordination and information exchange in maintaining procedural discipline.

Similarly, procedural practicality was a significant positive predictor ($\beta = 0.29$, $p < 0.001$), indicating that procedures perceived as realistic and feasible are more likely to be consistently followed by aviation personnel.

Interestingly, training and competence demonstrated a negative but statistically significant coefficient ($\beta = -0.19$, $p = 0.010$). This result may reflect overlapping variance with organizational factors such as safety culture and communication, suggesting that the independent contribution of training becomes less pronounced when broader organizational influences are taken into account.

In contrast, fatigue and workload, time pressure, and just culture did not show statistically significant independent effects in the regression model, despite their significant bivariate correlations with safety compliance. This indicates that their influence on compliance may be mediated through organizational and procedural factors rather than acting as direct predictors.

Discussion

The present study aimed to examine the influence of human factors on aviation safety compliance among airport and airline personnel, adopting a behavioral and organizational perspective consistent with contemporary aviation safety management approaches. In line with international safety frameworks, aviation safety is increasingly understood as an emergent property of socio-technical systems in which organizational culture, leadership, and human performance interact with operational demands (ICAO, 2023; EASA, 2024).

Overall model interpretation. The multiple linear regression model demonstrated very high explanatory power, accounting for 95.5% of the variance in aviation safety compliance ($R^2 = 0.955$; Adjusted $R^2 = 0.952$; $F(7,112) = 341.6$; $p < 0.001$). This finding provides strong quantitative evidence that aviation safety compliance is not a random or purely individual behavior, but rather a structured outcome shaped by a combination of human and organizational factors.

The regression model can be expressed as follows:

Safety Compliance = $\beta_0 + \beta_1$(Fatigue) + β_2 (Time Pressure) + β3 (Training) + β_4 (Communication) + β_5 (Safety Culture) + β_6 (Just Culture) + β_7 (Procedural Practicality) + ε (*where β_0 represents the intercept, β_1–β_7 denote the regression coefficients of the respective predictors, and ε represents the error term*). This formulation reflects the contemporary understanding of compliance as a behavioral construct influenced by multiple interacting dimensions rather than by regulatory enforcement alone.

Organizational human factors and hypothesis H1. The results provide strong support for Hypothesis H1, which proposed that organizational human factors positively influence aviation safety

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compliance. Among all predictors, safety culture and management support emerged as the most influential factor ($\beta = 0.63$, $p < 0.001$), with an exceptionally strong bivariate correlation with compliance ($r = 0.97$, $p < 0.001$). This indicates that a one-standard-deviation increase in perceived safety culture is associated with a 0.63 standard-deviation increase in safety compliance, controlling for other factors.

These findings are fully consistent with ICAO's emphasis on leadership commitment and safety culture as the cornerstone of effective Safety Management Systems (SMS), where safety is embedded as an organizational value rather than treated as a procedural requirement (ICAO, 2023). Similarly, EASA safety reviews highlight that deficiencies in safety culture and management engagement remain persistent contributors to operational risk, particularly in human performance–related events (EASA, 2024).

In addition, communication and teamwork were identified as significant predictors of compliance ($\beta = 0.28$, $p < 0.001$), reinforcing the idea that aviation safety is fundamentally a collective activity. Effective communication facilitates shared situational awareness, timely coordination, and early identification of hazards—key elements emphasized in aviation psychology and human factors research (Flin et al., 2021).

Psychological human factors and hypothesis H2. Hypothesis H2, which posited that psychological human factors significantly influence safety compliance, received partial support. At the bivariate level, both fatigue and workload ($r = 0.39$, $p < 0.001$) and time pressure ($r = 0.43$, $p < 0.001$) were significantly correlated with compliance. However, these variables did not retain statistical significance as independent predictors in the multivariate regression model ($p > 0.05$).

This pattern suggests that the influence of fatigue and time pressure on compliance may be indirect or mediated through organizational mechanisms such as staffing policies, scheduling practices, operational planning, and supervisory oversight. Such an interpretation aligns with modern aviation psychology, which conceptualizes fatigue as a system-level risk managed through Fatigue Risk Management Systems (FRMS) rather than as an individual failure (ICAO, 2022; EASA, 2023).

A similar explanation applies to Just Culture, which demonstrated a strong positive correlation with compliance ($r = 0.92$, $p < 0.001$) but did not remain a unique predictor in the regression model ($p = 0.214$). This likely reflects conceptual overlap between just culture, safety culture, and communication, as all three constructs capture aspects of trust, openness, and fairness within the organization. Recent empirical studies in aviation psychology suggest that psychological safety primarily influences safety outcomes through voice behavior and communication processes, rather than acting as a direct determinant of compliance (Newman et al., 2021).

Training, procedural design, and overlapping effects. An interesting and theoretically meaningful finding concerns training and competence. While training demonstrated a very strong positive bivariate association with compliance ($r = 0.90$, $p < 0.001$), its standardized regression coefficient was negative ($\beta = -0.19$, $p = 0.010$). This apparent contradiction can be explained by shared variance and multicollinearity with organizational predictors such as safety culture and communication.

Rather than indicating a detrimental effect of training, this result suggests that training functions as an integrated component of the broader organizational safety system. When leadership support, communication, and procedural quality are controlled for, the unique statistical contribution of training diminishes. Similar patterns have been reported in applied aviation human factors research, where training effectiveness depends heavily on organizational context and managerial reinforcement (Salas et al., 2022).

In contrast, procedural practicality remained a significant independent predictor of compliance ($\beta = 0.29$, $p < 0.001$). This finding supports the human factors principle that procedures must be realistic, usable, and aligned with operational conditions. International safety investigations repeatedly show that procedural non-compliance often reflects impractical or poorly designed procedures rather than deliberate rule-breaking (FAA, 2022).

Joint effects and hypothesis H3. The strong overall performance of the regression model provides clear support for Hypothesis H3, confirming that human factors jointly predict aviation safety compliance. Importantly, the relative strength of predictors indicates that organizational and systemic factors outweigh purely individual psychological variables in explaining compliance behavior.

This conclusion aligns with the shift in global aviation safety thinking from error-focused approaches toward systemic models such as Safety-II and resilient performance, which emphasize how organizations enable safe behavior under varying operational conditions (Hollnagel, 2022).

Implications for aviation psychology and safety management. From an aviation psychology perspective, the findings underscore the need to prioritize organizational design, leadership behavior, and procedural usability when aiming to improve safety compliance. Psychological states such as fatigue and stress remain important, but their impact is most effectively mitigated through organizational interventions rather than individual-level enforcement.

For aviation organizations operating in developing or transitioning aviation systems, these results highlight the importance of strengthening safety culture, enhancing communication channels, and ensuring that procedures are both practical and supported by management. This approach is consistent with ICAO and EASA guidance, which emphasizes proactive safety management and human-centered system design as key strategies for reducing risk (ICAO, 2023; EASA, 2024).

Conclusions

This study investigated the influence of human factors on aviation safety compliance among airport and airline personnel using a quantitative approach. The findings confirm that safety compliance is primarily shaped by organizational and procedural factors, rather than by isolated individual characteristics.

The results of the multiple regression analysis indicate that safety culture and management support represent the strongest predictor of safety compliance, followed by communication and teamwork and procedural practicality. These findings highlight the critical role of leadership commitment, effective coordination, and realistic procedures in ensuring consistent adherence to safety requirements. Although psychological factors such as fatigue and time pressure were significantly associated with safety compliance at the

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bivariate level, their independent influence diminished in the multivariate model, suggesting that their effects are largely mediated through organizational mechanisms.

An important insight concerns training and competence, which demonstrated a strong association with safety compliance but did not emerge as an independent predictor when organizational factors were considered. This suggests that training effectiveness is closely embedded within the broader safety management system rather than functioning as a standalone determinant of compliance.

Overall, the study supports the view that aviation safety compliance should be addressed through a systemic and human-centered approach, emphasizing organizational culture, leadership behavior, and procedural design. These findings contribute to aviation psychology and safety research by providing empirical evidence on the behavioral determinants of compliance and offer practical guidance for strengthening safety management practices.

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