

Analysis of psychosocial factors associated with aviation accidents in Brazil

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Air accidents have been extensively studied due to their human, social, and operational impacts. Among the various factors associated with the occurrence of these events, the human factor occupies a prominent position in contemporary analyses of operational safety. In this context, this dissertation conducted a documentary analysis of the Final Aeronautical Accident Reports made available by the Center for Investigation and Prevention of Aeronautical Accidents (CENIPA), with the objective of analyzing the psychosocial factors associated with accidents that occurred in Brazilian civil aviation in the last five years, in light of the ISO 45003:2021 standard. The research adopted a descriptive and exploratory approach, based on a partial survey of the available reports, with identification, categorization, and analysis of the relative frequency of psychosocial factors classified according to the domains of the aforementioned standard. The results demonstrate the recurrence of factors related to work organization, cognitive demands, communication, organizational support, safety culture, and interpersonal relationships in the set of reports analyzed. The analysis of the results allows for the identification of patterns and trends in the psychosocial factors associated with human errors described in the investigated accidents, contributing to the understanding of psychosocial vulnerabilities present in the aeronautical context. The results provide technical support for reflections and preventive actions aimed at managing psychosocial risks and improving operational safety, respecting the methodological limitations of the study.

Keywords: Psychosocial factors; Human factor; Air accidents; Operational safety.

1. Introduction

Psychosocial risks at work have become increasingly relevant in occupational health due to their effects on the mental health, well-being, and performance of workers, especially in highly complex sectors such as aviation (Feijó et al. 2014, Itani 2009). In this context, operational safety depends not only on technical reliability but also on human performance in the face of high cognitive, emotional, and organizational demands. Technological advances have reduced technical failures but have intensified the mental load, the pressure for high performance, and the low tolerance for error, leading to overload, fatigue, and vulnerability to human error (Gonçalves Filho et al. 2011, Araújo et al. 2003, Carriço et al. 2015, Feijó et al. 2014, Itani 2009, Pereira et al. 2020).

Literature on safety in complex systems highlights the recurrence of human, organizational, and psychosocial factors in the genesis of accidents in high-risk sectors, reinforcing the need for analytical approaches of a systemic nature (Hawkins 1993, Gonçalves Filho et al. 2015, Lucas 1997, Reason 1990).

Classic and contemporary theoretical models, such as the Job Demands-Resources (JD-R) model, demonstrate the role of excessive demands and insufficient organizational resources in the deterioration of well-being and occupational performance (Bakker and Demerouti 2007, Gardell 1977, Kohn and Schooler 1973).

In parallel, there is a strengthening of the regulatory framework on psychosocial risks, both in Brazil — with the update of NR-1 — and internationally, with the publication of ISO

45003:2021, which systematizes these risks in domains related to work organization, social factors and operational conditions (Brazil 2020, Ministry of Health 2022).

Given this scenario, this study aims to analyze the psychosocial factors associated with aircraft accidents recorded in the CENIPA Final Reports over the past five years, in light of ISO 45003:2021, identifying their frequency, preponderance and recurring patterns, with a view to strengthening operational safety in civil aviation.

2. Theoretical Basis

2.1. Work, mental health, and psychosocial risks

Psychosocial risks in the workplace have gained prominence in occupational health due to their impacts on mental health, well-being, and worker performance. These risks are associated with work organization, management practices, working conditions, and social relationships in the workplace, and are fundamental to understanding contemporary working conditions. Mental health, defined as a state of well-being that allows individuals to develop their abilities, cope with life's demands, and work productively, can be compromised in organizational contexts marked by high demands, competitiveness, and a lack of support, autonomy, and recognition, favoring psychological distress (Vasconcelos and Faria 2008).

In this context, psychosocial factors are understood as aspects of the organization and working conditions that increase the likelihood of adverse effects on the physical and psychological health of workers, resulting from the interaction between the individual, the organization, and the work environment (INSPQ 2016).

2.2. Civil aviation, piloting, and the human factor

Civil aviation is characterized as a highly complex socio-technical system, in which advanced technology, rigorous operational procedures, and human performance interact inseparably. Piloting imposes high cognitive and psychological demands, requiring sustained attention, rapid decision-making, continuous monitoring, and emotional control.

Studies indicate that workload, psychological demands, and the level of control over activities are associated with fatigue, mental exhaustion, and psychological distress among pilots, factors that can compromise attention and situational judgment, with direct implications for operational safety (Feijó, Câmara and Luiz 2014, Itani 2009). Although aeronautical systems are highly automated, the human factor remains central to the safety of operations. According to ICAO (1998), humans are the most adaptable element of the aeronautical system, but also the most vulnerable to influences that can negatively affect their performance, reinforcing the relevance of pilots' mental health to operational safety.

2.3. Operational Safety and Investigation of Aeronautical Accidents

Operational safety in aviation is based on practices and systems aimed at preventing failures and ensuring the reliability of operations, with accident investigation as a central element. According to Annex 13 of the Convention on International Civil Aviation, these investigations are exclusively preventive in nature, with the objective of identifying factors associated with occurrences and preventing their recurrence, remaining independent of punitive or judicial processes.

In Brazil, the investigation and prevention of aeronautical accidents are carried out within the scope of the Aeronautical Accident Investigation and Prevention System (SIPAER), under the coordination of the Aeronautical Accident Investigation and Prevention Center (CENIPA). The technical reports produced follow a standardized methodology and criteria aligned with international guidelines, constituting a reliable documentary basis for descriptive and exploratory analyses of human, organizational, and psychosocial factors associated with aeronautical occurrences (BRAZIL 1986, CENIPA 2021).

2.4. Psychosocial risks according to ISO 45003:2021

The international standard ISO 45003:2021 establishes guidelines for occupational health and safety management focusing on the psychological health of workers, integrating with ISO 45001

management systems, highlighting the identification, assessment, and control of psychosocial risks as part of organizational risk management (ISO 2021). The standard guides the identification of psychosocial risks related to work organization, social factors in the work environment, and potentially hazardous physical conditions, equipment, and tasks, allowing for the systematization of these risks into defined analytical domains. These categories provide a structured methodological basis for the identification and classification of the psychosocial factors analyzed in the research, ensuring analytical consistency and alignment with recognized international references (ISO 2021).

2.5. Job Demands–Resources (JD-R) model and its interpretative application

The Job Demands–Resources (JD-R) model, proposed by Demerouti et al. (2001) and expanded by Bakker and Demerouti (2007, 2014), is widely used to understand the relationships between job characteristics, well-being, and worker performance. The model is based on the distinction between job demands, understood as physical, cognitive, emotional, or organizational requirements associated with psychophysiological costs, and job resources, defined as elements that help workers cope with these demands and promote motivation, engagement, and performance, such as autonomy, social support, and role clarity.

In the context of this research, the JD-R is adopted as an interpretative theoretical framework, without any causal explanatory claims, allowing an integrated analysis of how recurring combinations of high demands and insufficient resources in the work environment are associated with the psychosocial factors identified in the Final Reports examined. The articulation of this model with ISO 45003:2021 contributes to a consistent theoretical interpretation of the results, respecting the methodological limitations of the study (Demerouti et al. 2001, Bakker and Demerouti 2007, 2014).

3. Methodology

This research is characterized as a documentary study, of a descriptive and exploratory nature, based on the analysis of Aeronautical Accident Occurrence Reports made available by the Aeronautical Accident Investigation and Prevention Center (CENIPA), within the scope of the Aeronautical Accident Investigation and Prevention System (SIPAER). The study was based exclusively on official and publicly accessible documents, prepared according to standardized and institutionally recognized technical procedures, obtained through the CENIPA public bulletin database, available at: <https://sistema.cenipa.fab.mil.br/cenipa/paginas/relatorios/relatorios>.

The Civil Aviation Accident Occurrence Reports published by CENIPA between 2020 and 2024 were considered, provided they presented consolidated technical conclusions and were fully available to the public. This period covers contemporary civil aviation practices and reflects recent advances in investigation processes conducted within the scope of SIPAER. In this universe, estimated at approximately 411 final reports, 200 documents comprised the analyzed sample, after the systematic application of inclusion and exclusion criteria.

Only final reports related to civil aviation accidents with completed investigations were included. Reports referring to incidents and serious incidents were excluded, as the study prioritized events with materialized consequences, such as substantial damage to the aircraft, serious injuries, or fatalities, which tend to present greater investigative depth and technical detail on organizational and human factors. Occurrences of an exclusively military nature, ongoing investigations, and documents that did not present a detailed technical analysis of the contributing causes were also excluded.

The analysis carried out constitutes a partial census of the population of aeronautical accident reports available in the period considered, restricting itself to complete documents compatible with the previously defined criteria. The study is eminently descriptive in nature, oriented towards the identification, systematization, and analysis of patterns and recurrences of psychosocial factors, not aiming to

establish causal relationships. The data were systematically organized, coded, and subjected to descriptive statistical analysis, with the calculation of absolute (occurrences) and relative frequencies.

The identification, categorization, and analysis of psychosocial factors were carried out based on the International Standard ISO 45003:2021, which guided the classification of results in the domains of work organization, social factors at work and work environment, equipment and hazardous tasks, ensuring methodological standardization and alignment with international normative references (ISO, 2021). When a factor presented characteristics potentially associated with more than one domain, the classification was carried out based on the contextual analysis of the excerpt from the investigative report, with each occurrence being coded only once in the domain considered most directly related to the described event, in order to avoid double counting and ensure consistency in the data analysis.

4. Results and Discussion

4.1. Work Organization (Domain 1 of ISO 45003:2021)

The assessment of air accident reports, based on the domain of Table 1 of ISO 45003:2021 (Work Organization), highlighted the predominance of psychosocial factors associated with how work is organized.

Table 1 – Frequency distribution of psychosocial risk factors related to work organization according to ISO 45003:2021 domains, based on accident reports from 2020 to 2024

Domain	Occurrence	Freq (%)
* Decision Making and Operational Judgment	112	12,58%
* Supervision, Support, and Operational Monitoring	103	11,57%
* Overload, Cognitive Demands, and Attention	70	7,87%
* Procedures, Standards, SOPs, and Compliance	60	6,74%
* Work Planning and Organization	206	23,15%

Risk Management, * Operational Safety, and Compliance	138	15,51%
* General Organizational Factors (Management, Change, Structure)	168	18,88%
* Competence, Experience, Training, and Skill	33	3,71%
Total	890	100,00%

As demonstrated in Table 1, which consolidates the absolute and relative frequency distribution of the identified factors, 890 occurrences were recorded, of which more than 70% are concentrated in the categories of Work Planning and Organization (206 occurrences; 23.15%), General Organizational Factors (168 occurrences; 18.88%), Risk Management, Operational Safety and Compliance (138 occurrences; 15.51%), and Operational Decision Making and Judgment (112 occurrences; 12.58%). This result indicates that the most relevant psychosocial risks related to the analyzed reports are associated with structural and managerial aspects.

The Work Planning and Organization domain, which presented the highest frequency in Table 1, demonstrates that deficiencies in operational planning, task definition, resource allocation, and activity coordination are recurring psychosocial factors in the analyzed events. According to ISO 45003:2021, such weaknesses tend to increase mental load, reduce task predictability, and compromise the ability to respond safely in complex socio-technical systems, such as the aeronautical sector. These results corroborate the literature that characterizes inadequate planning as a latent organizational failure, favoring human errors and unsafe decisions (Rodrigues, Faiad and Facas 2020, Derdowski and Mathisen 2023).

General Organizational Factors, responsible for 18.88% of occurrences, according to Table 1, reinforce the influence of institutional policies, decision-making processes, change management, and organizational culture on behavior and risk perception. Complementarily, the high incidence in the domain of Risk Management, Operational Safety, and Compliance (138 occurrences; 15.51%) highlights the interdependence between

psychosocial risks and formal safety management systems. As guided by ISO 45003:2021, inadequate risk management practices, associated with pressure for productivity or achievement of goals, intensify cognitive and emotional demands, reducing operational safety margins.

The categories Decision Making and Operational Judgment (112 occurrences; 12.58%) and Overload, Cognitive Demands and Attention (70 occurrences; 7.87%), also presented in Table 1, indicate that decisions under pressure, the need for continuous attention and the simultaneous processing of information are relevant elements in the air accidents analyzed. From the perspective of the Demand-Control and Demand-Work Resources (DRT) models, the results suggest a scenario of high cognitive demands that are not sufficiently compensated by organizational resources, such as support, clarity of roles and autonomy in decision-making (Rodrigues, Faiad and Facas 2020).

Finally, although the domains of Supervision, Operational Support and Monitoring, Procedures, Standards, SOPs and Compliance, and Competence, Experience, Training and Skills have lower relative frequencies in Table 1, these results reinforce that weaknesses in organizational support, standardization, and professional qualification also contribute to exposure to psychosocial risks. Overall, the results support the systemic approach proposed by ISO 45003:2021, demonstrating that psychosocial risks in aviation accidents predominantly stem from organizational and structural working conditions.

4.2.Social Factors at Work (Domain 2 of ISO 45003:2021)

The analysis of psychosocial factors related to the social aspects of work, according to the domains of ISO 45003:2021, totaled 944 occurrences, highlighting the predominance of the categories: Interpersonal Relationships, Organizational Culture, and Social and Organizational Support, which together represent approximately (826 occurrences; 87.5%) of the total identified (Table 2).

Table 2 – Frequency distribution of psychosocial risk factors related to social aspects of work according to

ISO 45003:2021 domains, based on accident reports from 2020 to 2024

Domain	Occurrence	Freq (%)
* Violence, Harassment, Bullying, and Victimization	35	3,71%
* Supervision	52	5,51%
* Interpersonal Relationships	375	39,72%
* Recognition and Reward	23	2,44%
* Leadership (style, support, and decision-making)	5	0,53%
* Career Development	3	0,32%
* Organizational Culture / Work Group Culture	244	25,85%
* Social and Organizational Support	207	21,93%
Total	944	100,00%

The Interpersonal Relationships domain showed the highest frequency, indicating that conflicts, communication failures, and weaknesses in work interactions constitute the most recurrent psychosocial factors, in line with Jacinto and Tolfo (2017) and Dejours (2015), who highlight the central role of social relationships in psychological well-being and job security. The high participation of the Organizational Culture domain reinforces the influence of institutional values, norms, and practices in intensifying occupational stress and generating latent conditions for organizational failures (Reason 1990, Carlotto et al. 2018). Complementarily, the relevance of Social and Organizational Support confirms that the absence of institutional support potentiates the adverse effects of high work demands, according to the Demand-Control-Social Support and Job Demands-Resources models (Leka and Cox 2010, Derdowski and Mathisen 2023). Although less frequent (87 occurrences; 9.22%), the categories of Supervision and Violence, Harassment and Intimidation maintain analytical relevance due to their high potential impact on mental health, reinforcing the pertinence of ISO 45003:2021 as

a reference for preventive interventions of a systemic nature.

4.3. Work environment, equipment and hazardous tasks (Domain 3 of ISO 45003:2021)

Table 3 summarizes the distribution of 666 occurrences of factors related to the work environment, equipment, and hazardous tasks, allowing for an integrated analysis of the results and discussion of psychosocial risk and operational safety parameters.

Table 3 – Frequency distribution of psychosocial risk factors related to the work environment, equipment, and hazardous tasks according to ISO 45003:2021 domains, based on accident reports from 2020 to 2024

Domain	Occurrence	Freq (%)
* Safety Barrier;	7	1,05%
* Working at low heights and exposure to physical hazards;	58	8,71%
* Infrastructure, resources, and operational support;	141	21,17%
* Equipment, systems, and maintenance;	61	9,16%
* Environmental conditions and physical-operational context;	248	37,24%
* Cognitive demands, attention, and operational pressure;	151	22,67%
Total	666	100,00%

It can be observed that the category Environmental conditions and physical-operational context presented the highest frequency (248 occurrences; 37.24%), demonstrating that variables such as adverse environmental conditions, physical characteristics of the environment, and instability of the operational context are the main factors associated with the analyzed occurrences. This finding is in line with Carlotto et al. (2018) who recognize the physical environment as a critical element in the genesis of occupational risks, especially in complex socio-technical systems, in which small environmental variations can

compromise human performance and the overall safety of operations.

Next, cognitive demands, attention, and operational pressure stand out, in the same way as the categories of domain 1: decision-making and judgment, the categories of domain 3 indicate that mental overload, the need for continuous vigilance, and decisions under pressure are the most relevant factors, with 151 occurrences (22.67%). These results are directly justified by theoretical models such as Demand-Control and Work Demands-Resources, which indicate that high cognitive demands, when not compensated by adequate resources, increase the risk of human error and adverse events (Feijó, Câmara and Luiz 2014, Derdowski and Mathisen 2023).

The Infrastructure, Resources and Operational Support category presented 141 occurrences (21.17%), reinforcing the importance of organizational and material factors, such as resource availability, technical support and operational planning. According to Neto (2015), deficiencies in these aspects act as latent failures, creating conditions conducive to the occurrence of incidents and accidents. Thus, these factors do not act in isolation, but interact with cognitive and environmental demands, increasing the risk potential.

The categories Equipment, systems and maintenance (61 occurrences; 9.16%) and Work at low heights and exposure to physical risks (58 occurrences; 8.71%) have lower frequencies, but are still relevant, representing classic risks that, when combined with organizational and psychosocial factors, can aggravate the consequences of the events analyzed. Finally, the low frequency of the Safety barriers domain (7 occurrences; 1.05%) may indicate underreporting or less analytical emphasis on identifying these organizational defenses.

The results of domain 3 indicate that more than 80% of the occurrences are associated with environmental, organizational and cognitive factors, corroborating the need for systemic preventive approaches, as recommended by ISO 45003:2021, with interventions that articulate improvements in the physical environment, in the management of mental demands and in strengthening the infrastructure and operational support.

4.4. Relationship between domains

Among the domains analyzed in the CENIPA aeronautical accident reports, in light of ISO 45003:2021, the highest frequency of occurrences associated with Interpersonal Relationships was observed, totaling 375 records. Next, Environmental Conditions and Physical-Operational Context stood out, with 248 occurrences, and finally, the category Planning and Organization of Work, with 206 occurrences.

In the set of the most frequent categories, previously highlighted, the most recurrent psychosocial risk factors are also observed, correspondingly. In the Interpersonal Relationships category, Ineffective Communication stands out, with 95 occurrences. In the Environmental Conditions and Physical-Operational Context category, the Hazardous Physical Environment factor stands out, with 66 occurrences. Finally, in the Work Planning and Organization category, the Inadequate Work Planning factor had the highest frequency, totaling 128 occurrences.

The analysis of the reports demonstrated that the domains Interpersonal Relationships, Environmental Conditions and Physical-Operational Context, and Work Planning and Organization do not manifest themselves in isolation, but are articulated systemically in the genesis of adverse events, reinforcing the socio-technical nature of aeronautical operations.

It was observed that failures in interpersonal relationships, especially those associated with ineffective communication, tend to potentiate the effects of adverse physical environments and unstable operational contexts, while deficiencies in work planning and organization increase workers' exposure to cognitive, emotional, and operational pressures. This interrelationship between domains shows that organizational, environmental, and relational factors feed back into each other, creating conditions conducive to human error and the degradation of safe performance.

5. Conclusion

This article demonstrated that psychosocial risks constitute relevant, recurring, and

interdependent factors in the analyzed aviation context, exerting a direct influence on the health, well-being, and performance of workers, as well as on organizational safety.

The results therefore reinforce the understanding that psychosocial risks should not be treated in a fragmented or residual manner, but systematically integrated into occupational health and safety management processes. The adoption of preventive approaches, based on the early identification of hazards, the active participation of aircrew, and the strengthening of protective factors—such as effective communication, organizational support, and consistent leadership—is essential for mitigating adverse impacts on operational safety.

It is concluded that the incorporation of the ISO 45003:2021 guidelines represents a significant advance in the structured tackling of psychosocial risks, by promoting an integrated vision between psychological health, work organization, and operational safety. Finally, it is important to highlight the need for further studies on aircraft accidents that explicitly consider the interaction between psychosocial domains, in order to support continuous interventions and more effective organizational policies aligned with the contemporary demands of the aviation sector.

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