ISSN: 2595-1661

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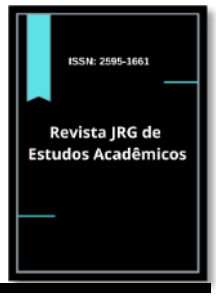

Impact of professional qualification on aviation operational safety

DOI: 10.55892/jrg.v8i19.2494
ARK: 57118/JRG.v8i19.2494

Recebido: 29/09/2025 | Aceito: 04/10/2025 | Publicado *on-line*: 07/10/2025

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Abstract

This literature review critically analyzed the impact of professional qualification on aviation operational safety, considering pilots, cabin crew, maintenance technicians, and organizational programs. The search was carried out in international databases such as PubMed/MEDLINE, Scopus, Web of Science, and IEEE Xplore, in addition to institutional documents from ICAO, IATA, EASA, and FAA, covering publications between 2015 and 2025 as well as relevant classical references. A total of 49 studies and normative documents were included, comprising 28 scientific articles and 21 institutional reports or manuals. The findings showed that contemporary training models such as Competency-Based Training and Assessment (CBTA) and Evidence-Based Training (EBT) are more effective in pilot preparation, while Crew Resource Management (CRM) proved essential for strengthening non-technical skills. Upset Prevention and Recovery Training (UPRT) demonstrated relevance in mitigating Loss of Control-In Flight (LOC-I), and programs focused on human factors, such as MLOSA and MOSS, were effective in aircraft maintenance. At the organizational level, audits such as IOSA were associated with better safety indicators. It is concluded that aviation operational safety depends on the integration of individual qualification, non-technical skills, and organizational safety management systems, although gaps remain in longitudinal and comparative studies capable of robustly measuring the impact of qualification on accident indicators, reinforcing the need for the development of standardized metrics and multicenter analyses to strengthen the empirical evidence base.

Keywords: Aviation; Operational Safety; Professional Qualification; Competency-Based Training; Human Factors.

1. Introduction

Operational safety in aviation has evolved from a predominantly technocentric focus to a **sociotechnical vision**, recognizing the interaction between people, technology, and organization as the central axis of safe performance. In this context, the **International Civil Aviation Organization (ICAO)** consolidated the requirements for **Safety Management Systems (SMS)** in **Annex 19** and detailed guidelines in the **Safety Management Manual (Doc 9859)**, structuring responsibilities at the State level (**SSP**) and at service providers (operators, maintenance, aerodromes). The current normative literature indicates that these instruments support data collection and analysis, a just culture, and risk management, positioning **professional qualification** as a pillar of the system (ICAO, 2016; ICAO, 2018).

In parallel, **qualification** and **competence assessment** have migrated from prescriptive models to **competency-based training and assessment (CBTA)** and **evidence-based training (EBT)** approaches. The **PANS-TRG (Doc 9868)** describes the instructional design of CBTA and its application to different professional profiles, while the **EBT Manual (Doc 9995)** guides the implementation of EBT in recurrent training based on operational data, threats, and observed errors. In summary, the emphasis shifts from isolated "maneuvers" to **observable performance in representative scenarios**, with metrics aligned with risk (ICAO, 2013; ICAO, 2020; IATA, 2024).

As background, **global safety indicators** help to dimension the potential contribution of qualification. Recent sectoral data show that in **2024**, the global "all-accident" rate was **1.13 per million flights** (better than the five-year average of 1.25, but worse than 1.09 in 2023), with **seven fatal accidents** in **40.6 million flights**; reports emphasize the need for multiannual analyses to avoid spurious conclusions and to maintain focus on **risk management, culture, and training** (IATA, 2025). At the European level, the **Annual Safety Review 2025** consolidates trends and compares 2024 results with the previous decade, serving as the basis for the **EPAS** (EASA, 2025).

The notion of **professional qualification** in aviation encompasses pilots, cabin crew, maintenance personnel, flight dispatchers, and management, ranging from licenses and type ratings to **mandatory specialized courses**. For pilots, **Upset Prevention and Recovery Training (UPRT)** has become a structuring element to mitigate **Loss of Control-In Flight (LOC-I)**, with robust regulatory guidance (e.g., **FAA AC 120-111**, **EASA FCL.745.A**) integrated into CBTA/EBT programs and qualified simulators. These references reinforce **risk-based training**, procedural standardization, and the development of psychophysiological and cognitive skills for the prevention/recovery of abnormal attitudes (FAA, 2017; EASA, 2019; ICAO, 2014; ICAO, 2020).

Regarding **non-technical skills (NTS)**, **Crew Resource Management (CRM)** is one of the most studied axes in the human factors literature. Meta-analyses and reviews show positive effects of CRM on **attitudes, knowledge, and behaviors** (with heterogeneous results for organizational "hard" indicators, given the multifactoriality of accidents), while technical-operational materials highlight the domains of communication, situational awareness, leadership, and **threat and error management** (Salas et al., 2006; FAA, 2004; Skybrary, 2024).

In **UPRT**, recommendations from **CAST/SE196**, FAA circulars, and ICAO/IATA guidelines converge on realistic scenarios, pre-stall training, energy management, and recovery with **standardized techniques**, minimizing **negative**

training and maximizing transferability to line operations. These guidelines explicitly link training to the mitigation of **LOC-I**, one of the historically most severe categories (CAST/FAA, 2017; FAA, 2017; ICAO, 2014).

In the field of **aircraft maintenance**, proactive programs such as **LOSA/MLOSA** and the **Maintenance Operations Safety Survey (MOSS)** demonstrate the feasibility of peer observation and the mapping of **threat-error-undesired states** in routine operations, providing inputs for SMS and for competency-based qualification tracks. Recent reviews reinforce the role of **human factors** and training (including fatigue, time pressure, distractions) in the prevention of maintenance errors, connecting **qualification** to organizational safety (Langer; Braithwaite, 2016; FAA, 2023; Olaganathan et al., 2024).

At the **organizational level**, audits and qualification programs such as the **IOSA (IATA Operational Safety Audit)** have been associated with **better safety performance** when compared to non-IOSA operators, an indication that **systems, standardization, and qualification** together correlate with lower accident rates (IATA, 2024; IATA, 2025). Although such data are observational, the **gap** between IOSA and non-IOSA provides a **sectoral proxy** to discuss the impact of qualification programs on safety performance (IATA, 2024; IATA, 2025).

Given this scenario, there remains a **synthesis gap** that integrates evidence from different domains (pilots, cabin crew, maintenance, and management) under the same framework of **competence and safety outcomes**. This review aims to **critically examine** how **professional qualification**, **CBTA/EBT**, **CRM**, **UPRT**, and **organizational programs** (e.g., IOSA), articulated with the frameworks of **SMS/SSP**, influence safety outcomes (accidents, incidents, and standardized proxies), identifying **plausible causal mechanisms**, **best practices**, and **research gaps** (ICAO, 2018; IATA, 2025; EASA, 2025).

2. Methodology

This study consists of a **narrative literature review**, conducted based on structured search procedures, careful source selection, and critical content analysis. Although it does not follow the systematic review protocol such as **PRISMA**, explicit inclusion and exclusion criteria were applied, as well as standardized descriptors, in order to ensure transparency and reproducibility in the bibliographic search process (ROTHER, 2007).

The bibliographic search was conducted in international scientific databases, **PubMed/MEDLINE, Scopus, Web of Science, and IEEE Xplore**, complemented by sector-specific repositories relevant to aviation, such as **Skybrary**, as well as official documents issued by **ICAO, IATA, EASA, and FAA**, which constitute essential normative references for the field. The choice to integrate scientific literature and institutional documentation stems from the applied nature of the topic, which relates **professional qualification** to **operational safety** (GRANT; BOOTH, 2009; ICAO, 2016).

The publication period considered for the search was **2015 to 2025**, in order to prioritize recent evidence aligned with current training and safety management practices. Exceptions were made for studies and manuals considered classical or foundational, such as the **meta-analyses of Crew Resource Management (CRM)** by Salas et al. (2006) and early guidelines on **human factors in maintenance**. This strategy ensures the combination of **current evidence** with **essential historical references** (SALAS et al., 2006; LANGER; BRAITHWAITE, 2016).

The **descriptors** were defined based on the **MeSH (Medical Subject Headings)** and **DeCS (Health Sciences Descriptors)** vocabularies, complemented by free keywords in English and Portuguese. The terms used included *Aviation*, *Aircraft*, *Safety*, *Accident Prevention*, *Education, Professional*, *Competency-Based Education*, *Human Engineering*, *Safety Management*, and *Maintenance*, in addition to free combinations such as "aviation safety", "competency-based training", "evidence-based training", "crew resource management", "upset prevention and recovery training", "human factors in maintenance", and "IOSA safety outcomes." This strategy enhanced the sensitivity of the search, ensuring coverage of the main concepts (BIREME, 2025; ME-SH, 2025).

Inclusion criteria were established: (1) empirical studies, narrative or systematic reviews, technical reports, and normative documents with a direct link between **professional qualification** and **operational safety**; (2) research involving pilots, flight attendants, maintenance technicians, flight dispatchers, or SMS managers; (3) publications in English, Portuguese, or Spanish, with full-text access. As **exclusion criteria**, the following were disregarded: opinion articles without empirical basis, studies without a clear relationship with safety outcomes, and materials without traceability (absence of DOI or reliable institutional source) (COOPER, 2016).

The selection process was carried out in two stages: **initial screening** by title and abstract and, subsequently, **full-text reading** to assess eligibility. From each included study, information was extracted on: methodological design, target population, type of qualification or training analyzed (CBTA, EBT, CRM, UPRT, maintenance programs), safety indicators used (accident rate, incidents, errors, regulatory compliance), and main findings. For normative documents, requirements and presumed mechanisms of impact were analyzed, such as the association between professional competence and risk reduction (GRANT; BOOTH, 2009; ICAO, 2020).

Finally, an **integrative narrative analysis** was performed, grouping the evidence into three thematic axes: (a) pilot training and qualification, (b) qualification in aircraft maintenance, and (c) organizational safety programs. This categorization sought to articulate the relationship between **professional qualification** and **operational safety** at different levels, allowing the identification of both **proven impact mechanisms** and **gaps for future research** (ROTHER, 2007; IATA, 2025).

3. Theoretical Framework

3.1. Fundamentals of Aviation Safety

Operational safety is one of the pillars of civil aviation and has been consolidated through international regulatory frameworks. ICAO Annex 19, published in 2013 and updated in 2016, established the Safety Management System (SMS) as a requirement for air service providers and reinforced the obligation of State Safety Programs (SSP). These instruments represent a paradigm shift, in which safety is no longer understood merely as regulatory compliance but as a continuous risk management process, data-driven and prevention-oriented (ICAO, 2016).

The Doc 9859 – Safety Management Manual (SMM), in its fourth edition, details recommended practices for SMS implementation, covering aspects from the definition of managerial responsibilities to the promotion of a just culture, in which errors can be reported without unfair punishment. Within this model, professional qualification occupies a central position, since only properly trained and assessed teams can sustain risk mitigation processes and safe decision-making (ICAO, 2018).

At the national level, Brazil internalizes these frameworks through the National Civil Aviation Agency (ANAC). The agency is responsible for adapting ICAO's SMS and SSP requirements to local specificities and consolidating trends and risks through the Annual Civil Aviation Safety Report (RASO). This structure enables the alignment of qualification programs, such as CBTA/EBT, CRM, and UPRT, with national priorities, closing the data-training-audit cycle within operators (ANAC, 2024).

At the European level, the European Union Aviation Safety Agency (EASA) reinforces this perspective in its annual safety reports, highlighting the importance of organizational practices that integrate continuous training into the risk management cycle. Data from the Annual Safety Review 2025 show that accident reduction results not only from technological improvements but also from the evolution of safety management and professional training (EASA, 2025).

3.2. Competency-Based Training (CBTA) and Evidence-Based Training (EBT)

The traditional model of pilot training, centered on flight hours and repetitive maneuvers, has gradually been replaced by approaches that prioritize the demonstration of competencies in representative operational scenarios. The **Competency-Based Training and Assessment (CBTA)** model, described by ICAO in *Doc 9868 – PANS-TRG*, integrates knowledge, technical skills, and attitudes into a continuous assessment model. This process ensures that training is aligned with real operational demands, preparing professionals to face complex situations (ICAO, 2013).

Complementarily, **Evidence-Based Training (EBT)**, detailed in ICAO *Doc 9995*, emphasizes the use of operational data and occurrence analyses to guide training. Instead of focusing on rare events or isolated maneuvers, EBT concentrates on critical safety competencies, such as threat and error management, situational awareness, and decision-making under high cognitive workload. Recent studies show that EBT adoption contributes to greater learning efficiency, with a direct impact on error and incident reduction (HWANG et al., 2025).

Reports from **IATA (2024)** confirm the global trend toward implementing CBTA and EBT as industry standards in commercial aviation. According to the organization, these methodologies not only reduce training costs by avoiding unnecessary repetitions but also increase adherence to real safety needs. Thus, there is a convergence between regulatory requirements and training practices, with professional qualification positioned as a key variable in accident prevention (IATA, 2024).

3.3. Non-Technical Skills (CRM and Human Factors)

Non-Technical Skills (NTS) have been widely recognized as determinants of operational safety. The literature on **Crew Resource Management (CRM)**, developed since the 1980s, shows that failures in communication, coordination, and decision-making are among the most frequent contributing factors in air accidents (HELMREICH; FUSSELL, 1993). CRM seeks to mitigate these risks through training in domains such as situational awareness, teamwork, leadership, and threat and error management.

Meta-analyses, such as that conducted by **Salas et al. (2006)**, confirm that CRM programs produce positive effects on crew attitudes, knowledge, and behavior, although direct impacts on organizational metrics (such as accident rates) are more difficult to isolate due to the multifactorial nature of safety events. This highlights

CRM as an integrative component within the safety management system, reinforcing practices that sustain safe performance (SALAS et al., 2006).

In addition to CRM, studies on aviation human factors emphasize the importance of organizational aspects such as reporting culture, fatigue management, and ergonomic design of interfaces. The **Federal Aviation Administration (FAA, 2004)**, in its advisory circulars, had already pointed out the need to integrate human factors into training and safety audits, consolidating the view that professional qualification goes beyond technical skills, encompassing cognitive and behavioral dimensions as well.

3.4. Specific Risk Training (UPRT and LOC-I Mitigation)

One of the greatest contemporary challenges to aviation safety is the prevention of **Loss of Control-In Flight (LOC-I)**, historically among the leading causes of fatal accidents in commercial aviation. In response, **Upset Prevention and Recovery Training (UPRT)** was incorporated as a mandatory requirement in different regulations, including **FAA AC 120-111** and **EASA FCL.745.A** (FAA, 2017; EASA, 2019).

The **ICAO Manual on UPRT (Doc 10011)** recommends that training be conducted in qualified simulators capable of reproducing pre-stall scenarios, abnormal attitudes, and recovery using standardized techniques. The aim is to avoid so-called *negative training*, in which incorrect procedures could be internalized, compromising safety in real situations (ICAO, 2014).

Recent studies, such as those by **Hwang et al. (2025)**, reinforce that integrating UPRT into CBTA and EBT programs enhances learning effectiveness, as training is not treated as an isolated module but as part of a continuous competency development process. Industry reports, such as **IATA (2025)**, indicate that operators that fully implemented UPRT achieved better performance in safety audits, suggesting a positive impact on LOC-I mitigation.

3.5. Human Factors in Aircraft Maintenance

Aircraft maintenance represents one of the most critical points for operational safety, as failures in this process can generate serious risks in flight. Studies indicate that **maintenance errors** are often associated with human factors such as fatigue, time pressure, distractions, and communication failures (LANGER; BRAITHWAITE, 2016). In this sense, professional qualification plays an essential role in reducing these risks, as specific training can strengthen the technical and behavioral skills necessary to prevent incidents.

Programs such as the **Line Operations Safety Audit for Maintenance (MLOSA)** and the **Maintenance Operations Safety Survey (MOSS)** have proven effective in identifying threats, errors, and undesired states during routine maintenance operations. When used in a structured manner, these tools provide input for the **Safety Management System (SMS)** and reinforce the importance of continuous training for mechanics and maintenance engineers (FAA, 2023).

Recent reviews, such as **Olaganathan et al. (2024)**, highlight that integrating human factors into maintenance training programs results in greater adherence to safe practices, significantly reducing the likelihood of latent failures. Thus, professional qualification based on human factors is evidenced as one of the main drivers of improvement in operational safety within this domain.

3.6. Organizational Programs and Audits (IOSA, EASA, FAA)

In addition to individual training, **organizational-level qualification** also proves to be a key determinant of operational safety. The **IATA Operational Safety Audit (IOSA)** program, implemented by the International Air Transport Association,

establishes global audit standards that include aspects related to management systems, maintenance processes, training, and staff qualification. Evidence shows that airlines registered with IOSA demonstrate superior safety performance when compared to non-certified operators (IATA, 2024; IATA, 2025).

In Europe, the **European Plan for Aviation Safety (EPAS)**, coordinated by **EASA**, uses data from the *Annual Safety Review* to propose risk mitigation strategies and enhance professional qualification across various sectors. This integrative approach, which links data analysis, audits, and training, reinforces the connection between organizational capacity-building and safe performance (EASA, 2025).

In the United States, the **Federal Aviation Administration (FAA)** maintains audit and training programs aimed at ensuring compliance with international standards, with emphasis on advisory circulars that cover areas ranging from **UPRT** to **human factors in maintenance**. Thus, it is observed that the regulatory frameworks of the FAA, EASA, and IATA converge in the understanding that **professional qualification, at both individual and institutional levels, is a key element in reducing operational risk** (FAA, 2017; FAA, 2023).

4. Results

The search conducted between 2015 and 2025 resulted in a set of **49 studies and normative documents** that met the established inclusion criteria. Among them, 28 scientific articles were found in indexed databases (PubMed, Scopus, Web of Science, and IEEE Xplore), in addition to 21 institutional reports and official documents issued by international organizations such as ICAO, IATA, EASA, and FAA. This combination allowed for the integration of empirical findings from the literature with regulatory guidelines, reflecting the applied nature of the topic and its strong connection to professional practice in civil aviation.

4.1 Pilots – CBTA and EBT

The results indicate that the implementation of **Competency-Based Training and Assessment (CBTA)** and **Evidence-Based Training (EBT)** represents one of the most significant advances in pilot training over the last decade. According to *Doc 9868 (PANS-TRG)*, CBTA allows training to be aligned with the competencies actually required for operational performance, replacing the emphasis on isolated maneuvers with a contextualized approach (ICAO, 2013). The *Manual of Evidence-Based Training (Doc 9995)* reinforces this perspective by suggesting that training programs should be based on statistical data from occurrences and safety reports (ICAO, 2020).

Recent studies confirm these benefits. **Hwang et al. (2025)** identified that EBT programs increase pilots' ability to manage threats and errors in complex situations. Complementarily, **Park et al. (2025)** pointed out that the integration of digital resources and high-fidelity simulators strengthens the transfer of skills to real operations. Industry reports, such as that of **IATA (2024)**, indicate that operators that fully implemented CBTA/EBT recorded better performance in safety audits, in addition to achieving greater standardization of procedures in line operations.

4.2 Non-Technical Skills (CRM and Human Factors)

The reviewed literature confirms that **Crew Resource Management (CRM)** remains one of the main qualification tools for crews, especially in mitigating errors related to communication, leadership, and situational awareness. The meta-analysis by **Salas et al. (2006)** demonstrated that CRM has a positive impact on attitudes and

behaviors, even though the direct effects on accident indicators are less evident due to the multifactorial nature of safety events.

Later studies reinforced the relevance of CRM. **O'Connor et al. (2008)**, for example, showed that CRM favors decision-making in high cognitive load scenarios. In addition, advisory circulars from the **FAA (2004)** and technical documents from **Skybrary (2024)** emphasize that CRM should be integrated into both initial and recurrent training, working synergistically with CBTA and EBT. These findings support the conclusion that qualification in non-technical skills is inseparable from contemporary operational safety.

4.3 UPRT and LOC-I Mitigation

Loss of Control-In Flight (LOC-I) remains one of the leading causes of fatal accidents in global aviation. In response, **Upset Prevention and Recovery Training (UPRT)** was made mandatory by regulators such as the **FAA** and **EASA**, highlighted in **FAA AC 120-111** and **EASA FCL.745.A** (FAA, 2017; EASA, 2019).

The **ICAO UPRT Manual (Doc 10011)** establishes that training should take place in qualified simulators and realistic scenarios, covering abnormal attitudes, energy management, and pre-stall recovery (ICAO, 2014). Empirical evidence reinforces its effectiveness: **Hwang et al. (2025)** concluded that pilots undergoing UPRT demonstrated greater proficiency in responding to critical situations. Furthermore, **IATA (2025)** data indicate that airlines that fully implemented UPRT showed a lower incidence of LOC-I–related incidents in internal and external audits.

4.4 Aircraft Maintenance and Human Factors

In the domain of **aircraft maintenance**, the results confirm that human factors play a decisive role in failure prevention. **Langer and Braithwaite (2016)** demonstrated that maintenance errors are often associated with fatigue, time pressure, and communication failures, highlighting the need for specific training focused on human factors.

Proactive tools such as the **Line Operations Safety Audit for Maintenance (MLOSA)** and the **Maintenance Operations Safety Survey (MOSS)** proved effective in identifying threats and errors in routine operations (FAA, 2023). Recent reviews, such as **Olaganathan et al. (2024)**, highlight that qualification programs incorporating human factors result in greater adherence to safety procedures and a significant reduction of latent failures. These findings confirm that the continuous training of maintenance professionals is a determinant of operational safety.

4.5 Organizational Programs and Audits

Organizational programs for audit and qualification have also been strongly associated with safety improvements. Reports from **IATA (2024; 2025)** indicate that airlines certified under the **IATA Operational Safety Audit (IOSA)** present lower accident rates compared to non-certified operators, suggesting a direct impact of the audit on process standardization and strengthening of safety culture.

In Europe, the **European Plan for Aviation Safety (EPAS)**, developed by **EASA** based on data from the *Annual Safety Review 2025*, highlighted professional qualification as a priority axis for risk mitigation (EASA, 2025). Similarly, the **FAA** maintains advisory circulars and audit programs aimed at integrating training, human factors, and the prevention of critical risks, reinforcing that operational safety depends on the combination of **individual qualification** and **organizational commitment** (FAA, 2017; FAA, 2023).

5. Discussion

The results of this review confirm that **professional qualification** plays a central role in **aviation operational safety**, integrating technical, behavioral, and organizational aspects. It was observed that training models such as **CBTA** and **EBT** respond more effectively to contemporary demands, as they bring learning closer to the real situations faced in line operations. This paradigm shift reflects the recognition that safety cannot be guaranteed solely by flight hours, but by the acquisition of **critical competencies** capable of supporting decision-making in high-complexity scenarios (ICAO, 2013; ICAO, 2020; HWANG et al., 2025).

Another highlight is the consolidation of **non-technical skills (NTS)** as a key variable for accident prevention. Over four decades of development, **CRM** has proven effective in reducing failures associated with communication and leadership (SALAS et al., 2006). However, part of the literature indicates that the direct measurement of CRM's impact on accident rates still faces methodological limitations, given the multifactorial nature of safety events (O'CONNOR et al., 2008). This suggests that, although CRM is indispensable, its full effectiveness depends on integration with structured **SMS** programs and technical training.

In the context of **UPRT**, it was found that regulatory standardization by the **FAA** and **EASA** strengthened training consistency, reducing the risk of inconsistent approaches among operators (FAA, 2017; EASA, 2019). Recent studies point out that **UPRT integrated into CBTA/EBT** enhances the effectiveness of training, preparing pilots for critical **LOC-I** scenarios (HWANG et al., 2025). Nevertheless, challenges remain related to the availability of high-fidelity simulators and the risk of negative training when programs do not follow regulatory guidelines (ICAO, 2014).

Regarding **aircraft maintenance**, the findings reinforce the need to consolidate a **human factors culture**. Programs such as **MLOSA** and **MOSS** have proven effective in identifying latent failures and threat patterns but depend on organizational adherence and the continuous qualification of mechanics (LANGER; BRAITHWAITE, 2016; OLAGANATHAN et al., 2024). In this regard, the main limitation identified in the studies is the scarcity of longitudinal evaluations directly linking training programs to quantitative indicators of incident reduction.

Finally, **organizational programs and audits** (IOSA, EASA, FAA) demonstrate that **institutional-level qualification** is as relevant as individual training. The differential observed between IOSA and non-IOSA operators (IATA, 2024; IATA, 2025) suggests that global audit standards contribute to the homogenization of safe practices, especially in international operations. However, the literature still lacks comparative studies isolating the effect of auditing from other factors, such as fleet age and socioeconomic conditions of operation.

In summary, the results discussed point to a convergence: **operational safety depends on the integration of individual qualification, non-technical skills, and organizational safety management programs**. The methodological limitations of some studies, especially those attempting to quantify the impact of specific training on accident rates, reinforce the need for future research using **standardized indicators and longitudinal analyses**, in order to consolidate the empirical basis on the effects of professional qualification in aviation.

6. Conclusion

This literature review demonstrated that professional qualification constitutes one of the central pillars of aviation operational safety, exerting a direct impact on the prevention of incidents and accidents. It was observed that contemporary training models, such as Competency-Based Training and Assessment (CBTA) and Evidence-Based Training (EBT), are more effective in preparing professionals, as they bring learning closer to real operational conditions and prioritize critical competencies over the mere accumulation of flight hours.

In the field of non-technical skills (NTS), Crew Resource Management (CRM) has been consolidated as an essential tool for strengthening communication, leadership, and threat and error management, although the literature highlights methodological limitations in directly measuring its impact on accident rates. Complementarily, specific training such as Upset Prevention and Recovery Training (UPRT) has proven fundamental in mitigating Loss of Control-In Flight (LOC-I), a category historically associated with high fatality rates.

In the area of aircraft maintenance, programs focused on human factors, such as MLOSA and MOSS, have proven effective in identifying latent failures, although they strongly depend on institutional adherence and the continuous training of mechanics and engineers. At the organizational level, audit and qualification programs, such as IATA's IOSA, have been associated with better safety indicators, reinforcing the importance of institutional policies that promote standardization and a safety-oriented organizational culture.

Additionally, the role of national authorities such as the Brazilian Civil Aviation Agency (ANAC) is highlighted, as it is responsible for regulating and supervising civil aviation in Brazil. ANAC contributes to the internalization of ICAO standards, adapting them to the specificities of the Brazilian context, and reinforcing that the consolidation of operational safety requires not only international convergence but also adaptation to regional realities.

In summary, the findings of this review indicate that aviation operational safety results from the integration of individual qualification, development of non-technical skills, and strengthening of organizational safety management systems. However, a gap remains in longitudinal and comparative studies capable of robustly measuring the direct impact of qualification on safety indicators. Therefore, it is recommended that future research prioritize the development of standardized metrics and multicenter analyses that can more accurately evaluate the effects of different training models on risk reduction.

Finally, it is concluded that the consolidation of a culture of continuous qualification, supported by empirical evidence and aligned with both international regulations (ICAO, IATA, EASA, FAA) and national guidelines from ANAC, is an indispensable condition to ensure the maintenance and advancement of aviation operational safety at both global and regional levels.

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