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Research Paper

# Impact of Workload and Work-Life Balance on Aviation Safety at Soekarno-Hatta ATC

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**Abstract**

The increasing complexity of air traffic operations and the high cognitive demands placed on Air Traffic Controllers (ATCs) underscore the critical need to address factors affecting performance and safety. This study investigates the influence of workload and work-life balance (WLB) on safety outcomes among ATCs at Soekarno-Hatta International Airport through a Systematic Literature Review (SLR). This research is motivated by the growing concern over fatigue-related incidents in aviation, particularly in high-density airspace environments. By synthesizing empirical and theoretical findings from peer-reviewed literature, this study explores how excessive workload, rigid shift structures, and insufficient recovery periods contribute to cognitive fatigue, diminished attentional control, and elevated error rates. In contrast, structured WLB interventions—such as optimized shift rotations, mandatory rest periods, and supportive scheduling policies—are found to mitigate fatigue and enhance operational vigilance. However, the applicability of flexible working hours in ATC settings is constrained by the operational and regulatory frameworks of the aviation industry, particularly the standards set by the International Civil Aviation Organization (ICAO). This study contributes to the discourse on aviation human factors by advocating tailored fatigue risk management strategies and institutional support mechanisms to improve ATC well-being and ensure sustained aviation safety performance.

**Keywords:** *Workload, Work-life Balance, Aviation Safety, Air Traffic Service, Shift Scheduling, ICAO Regulation*

## INTRODUCTION

Aviation safety is a fundamental priority in global air transport operations and is governed by both national and international regulations. In Indonesia, aviation safety is mandated under Law (*Undang-Undang*) Number 1 of 2009, which defines it as the fulfillment of safety requirements in the use of airspace, aircraft, airports, air transportation, navigation services, and other supporting facilities. At the international level, the International Civil Aviation Organization (2020). has developed a comprehensive framework through its Standards and Recommended Practices (SARPs), which includes components such as the Safety Management System (SMS), incident reporting and investigation, compliance monitoring, and risk-based safety oversight. These frameworks are complemented by ICAO's emphasis on personnel competence, infrastructure adequacy, and efficient air traffic management to minimize operational risks.

Among the key actors in maintaining aviation safety are Air Traffic Controllers (ATCs), whose responsibilities are critical to the safe and efficient flow of air traffic. The ATC profession is widely recognized as one of the most mentally demanding occupations, given the complexity, time pressure, and life-or-death consequences associated with decision-making. Stress among ATCs is often linked to high workloads, especially during peak traffic periods or when disruptions occur due to adverse weather or equipment failures (Yulenda, 2018). Despite the acknowledgment of stress and cognitive workload in ATC roles, the real-world consequences of ignoring work-life balance (WLB) and workload regulation remain underemphasized in the literature. For instance, excessive workload and lack of rest are directly correlated with increased human error, reduced


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situation awareness, and diminished decision-making capacity, all of which compromise aviation safety (International Civil Aviation Organization, 2023). Poorly managed shift rotations and inadequate rest further intensify this stress, compromising psychological resilience and operational performance.

At major aviation hubs, such as Soekarno-Hatta International Airport, the intensity of air traffic magnifies these challenges. As one of the busiest airports globally, ranked 18th in 2017 with over 66.9 million passengers, the demand for ATC personnel is substantial. Ensuring safety in such high-density environments requires not only technological and procedural safeguards but also a human-centered approach that addresses the well-being of the controllers.

One critical dimension of ATC well-being is work-life balance (WLB), which encompasses not only time management but also psychological health and the ability to recover from work-related stress. While WLB is widely promoted in modern work culture as a means to enhance job satisfaction and productivity, its application in high-reliability organizations like air traffic control is complex. Unlike conventional office jobs, ATC schedules are governed by stringent safety requirements and operational continuity demands, limiting the scope of working hour flexibility. Although some sectors have benefited from flexible scheduling models, the feasibility and appropriateness of such practices in ATC remain uncertain and must be evaluated within the operational constraints and regulatory frameworks established by ICAO.

The implementation of WLB strategies in ATC contexts, particularly in developing countries such as Indonesia, presents a unique set of challenges. While previous studies have examined WLB in general workplaces (Greenhaus & Allen, 2011; Casper et al., 2018), very few have addressed the operational and regulatory constraints that make flexible scheduling difficult in critical safety roles. ICAO stipulates minimum rest periods and maximum duty hours to protect operational safety (International Civil Aviation Organization, 2023), yet leaves room for national discretion in shift design. However, the tension between these safety-driven scheduling principles and emerging flexible work models remains largely unexplored in empirical research. Although it is mentioned that WLB is difficult to apply in ATC, current studies fail to articulate the nature of that difficulty or how it intersects with regulatory frameworks such as those of ICAO or national civil aviation authorities.

Moreover, a notable geographical gap remains in the research. Most existing literature focuses on Western or developed aviation systems, leaving limited insights into how WLB and workload are perceived, managed, and institutionalized in Southeast Asian contexts. Stating that research is "limited" is insufficient without specifying the areas underexplored, such as the sociocultural norms of work, institutional inflexibility, and operational rigidity present in Indonesia's ATC environment. This study addresses this gap by offering an in-depth case of Soekarno-Hatta International Airport, one of the busiest hubs in Southeast Asia, to analyze how work demands, rest regulations, and performance expectations converge to affect both safety and employee well-being.

Therefore, this study offers an evidence-based evaluation of the ATC workload and WLB from a human-system logistics perspective. This study not only identified the factors affecting work-life conflict but also situates these findings within the broader aviation operational framework. By grounding the discussion in the tension between ICAO compliance, operational logistics, and human factors, this study aims to offer a context-sensitive framework that guides ATC scheduling, national policy reform, and performance optimization strategies. The findings are expected to contribute to theory by linking workload models with real-time operational logistics and to practice by informing aviation authorities of effective, safe scheduling systems that align with both safety and human sustainability

## LITERATURE REVIEW

Workload is a condition in which individuals are faced with job demands that vary in intensity, complexity, and difficulty, depending on the nature of the tasks and the context in which they are performed (Arasyandi, 2016). In the aviation sector, workload is particularly high because of the industry's inherent demand for precision, accuracy, and efficiency. These demands are directly linked to human safety, making workload management a critical factor in aviation operations. The workload is generally categorized into two main types: physical and mental workloads. Physical workload refers to bodily activities and manual tasks that require physical effort, such as moving equipment or maintaining posture for extended periods. In contrast, mental workload involves cognitive functions, including attention, memory, decision-making, and problem-solving processes. This includes responding to time constraints, processing large volumes of information, maintaining concentration over long periods, assessing task complexity, and meeting performance expectations. The mental dimension of workload is particularly prominent in aviation roles, such as air traffic controllers, pilots, and maintenance personnel, who must operate in high-stake environments where errors can have fatal consequences. Moreover, the workload is dynamic—it fluctuates with changing operational conditions and external stressors, thus requiring continuous monitoring and adjustment. If the workload exceeds an individual's capacity over prolonged periods, it can lead to mental fatigue, loss of concentration, decreased performance, and increased risk of human error. In aviation, such outcomes can compromise the safety of not only the workers themselves but also passengers and the public (Wulanyani, 2013).

Work-life balance (WLB) refers to an individual's ability to manage and harmonize personal and professional responsibilities effectively, ensuring that neither domain overwhelmingly infringes upon the other (Kossek & Lambert, 2005). In professions with high cognitive and psychological demands, such as Air Traffic Controllers (ATCs), the concept of WLB becomes exceptionally critical. ATCs are tasked with maintaining prolonged focus, operating under high-stress conditions, and making precise, split-second decisions that directly affect the safety of hundreds of lives during every shift (Briggs et al., 2012). The operational characteristics of ATC work frequently involve irregular work schedules, night shifts, and extended working hours, all of which can disrupt normal social and family activities. This irregularity highlights the need for flexible working arrangements that can accommodate personal needs while maintaining professional accountability. Research has consistently highlighted that job flexibility is a key determinant of mental health, well-being, and sustained productivity, particularly in roles characterized by intense psychological pressure. Flexibility may manifest in various dimensions, including adaptable shift patterns, opportunities for remote monitoring tasks when feasible, job-sharing arrangements, and reduced workload intensity during critical recovery periods. Studies have shown that providing flexibility not only alleviates stress and enhances employee satisfaction but also leads to better organizational outcomes, such as reduced turnover and fewer operational errors (Allen et al., 2014). Specifically, for ATCs, flexibility is intricately linked to adherence to rigorous safety protocols, as adequate rest and recovery are paramount to maintaining the cognitive sharpness and vigilance required for safe air traffic management (Costa, 2003). Thus, fostering effective WLB for ATCs is not merely a matter of employee welfare; it is a strategic necessity for ensuring operational safety, enhancing performance, and promoting long-term workforce sustainability in the aviation sector.

Aviation safety is the core pillar of air traffic control (ATC) operations and represents the foundation upon which the reliability and integrity of an entire air transportation system can be built. ATCs play a vital and indispensable role in maintaining the safety of all air traffic, ensuring the orderly, efficient, and secure coordination of aircraft movements both in the airspace and on the ground at airports. ATCs Their responsibilities demand precise, timely, and consistent

adherence to highly standardized safety procedures, as their real-time decisions are directly linked to the prevention of accidents, near misses, runway incursions, and other operational incidents (Kanki et al., 2010). Even minor communication or situational assessment errors can escalate into serious safety threats, underscoring the critical nature of their role. The safety framework that governs ATC operations is constructed through a multi-layered system involving comprehensive operational protocols, rigorous initial and recurrent training programs, strict regulatory oversight from aviation authorities, and the integration of sophisticated technological systems such as radar, Automatic Dependent Surveillance-Broadcast (ADS-B), and conflict detection tools. This systematic and proactive risk management approach is essential for maintaining a high standard of aviation safety.

The key elements central to ATC safety are effective communication, heightened situational awareness, and robust conflict detection and resolution capabilities. Effective communication, whether verbal via radio transmissions or digital via data links, forms the backbone of successful ATC operations, where clarity, brevity, and accuracy are paramount (International Civil Aviation Organization, 2020). To prevent misunderstandings, international procedures emphasize the standardized use of aviation phraseology, ensuring that instructions, clearances, and information exchanges are unambiguous and universally understood (Kerns, 1999). Situational awareness, defined as the ATC's ability to perceive environmental elements, comprehend their meaning, and project their future status, is another critical competency (Endsley, 1995). Maintaining high situational awareness requires ongoing simulation training, stress resilience programs, cognitive workload management, and familiarization with the evolving airspace complexities. In addition, conflict detection and resolution strategies are fundamental to safe operations. These include maintaining prescribed separation minima, proactive traffic sequencing, the issuance of timely conflict advisories, and the application of rerouting measures to prevent loss of separation and potential collisions (Eurocontrol, 2018). Overall, aviation safety within ATCs is a dynamic, multi-dimensional process that demands constant vigilance, adaptability, and collaboration across the aviation ecosystem.

## RESEARCH METHOD

This study employs a Systematic Literature Review (SLR) methodology, a well-established and structured approach for rigorously collecting, evaluating, and synthesizing existing literature within a defined research domain (Kitchenham, 2007). The SLR aims to provide a comprehensive, transparent, and reproducible overview of current knowledge, allowing researchers to identify research gaps, track emerging trends, evaluate the quality of evidence, and formulate robust conclusions to inform practice and future inquiry (Tranfield et al., 2003; Petticrew & Roberts, 2006).

To ensure methodological rigor, the review process followed a predefined protocol encompassing: (1) formulation of specific research questions; (2) systematic search using academic databases (e.g., Scopus, IEEE Xplore, ScienceDirect, etc); (3) screening based on inclusion and exclusion criteria; and (4) synthesis of key findings from the selected studies. The process adhered to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure clarity and reproducibility.

The PRISMA framework was adopted to illustrate a transparent screening and selection process. This framework is widely recognized for documenting how sources are identified, screened, and filtered to obtain the final sample. This approach helps reduce bias by clarifying the rationale behind the inclusion and exclusion of studies and enhances the methodological transparency of literature reviews.

For data analysis, a thematic synthesis approach was employed to extract patterns and group findings into key themes. However, rather than using a formal framework, such as a thematic map or coding matrix, themes were manually derived based on recurring concepts identified across the selected studies. Although this inductive process facilitated flexibility in theme development, it presents a limitation in terms of transparency and reproducibility, as no qualitative analysis software or structured coding protocol was used.

Furthermore, although the research topic focuses on air traffic control (ATC) procedures and work-life balance at Soekarno-Hatta International Airport, the review draws on international literature. This presents a contextualization challenge. While global findings offer valuable theoretical insights, the study does not include a framework for adapting or validating these findings within the specific operational, cultural, or regulatory context of Soekarno-Hatta. Future research could address this gap by incorporating primary data or case-specific validation strategies to enhance contextual relevance.

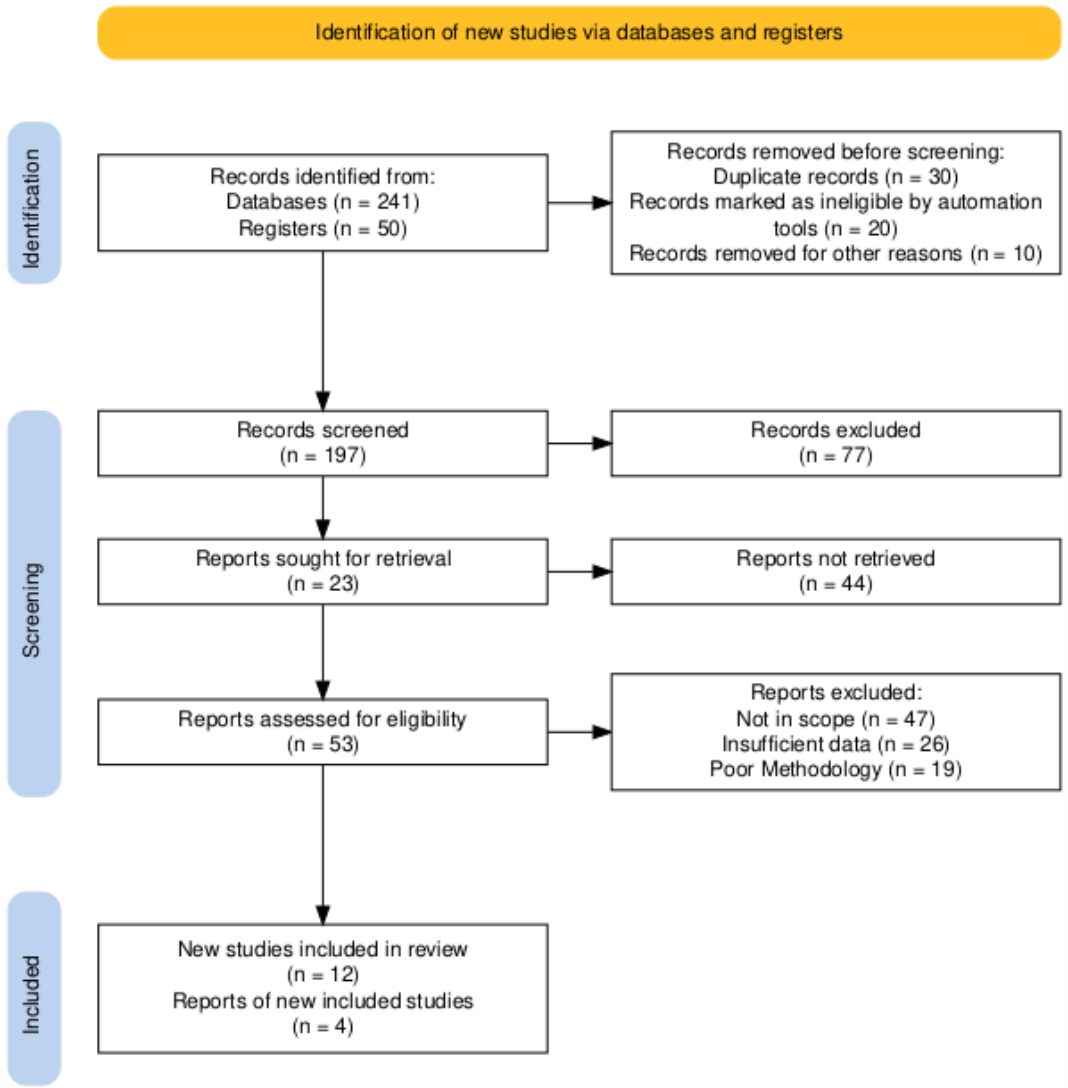


**Figure 1.** PRISMA Flowchart

By adopting the SLR methodology, this study ensures academic rigor and provides a strong foundation for understanding the interplay between work-life balance and safety procedures in air traffic control. Nonetheless, the limitations highlighted—particularly in thematic derivation, contextual relevance, and lack of structured tools—indicate opportunities for refinement in future studies.

**Research Objectives and Rationale for SLR**

The objectives of the SLR include (1) identifying key studies and practices relevant to work-life balance and safety for ATCs and (2) determining the relationship between work-life balance and ATC personnel at Soekarno Hatta Airport. SLR ensures objectivity and rigor by following a structured methodology, which minimizes bias and maximizes the reliability of the findings (Tranfield et al., 2003). The decision to employ SLR in this research stems from the critical importance effect of work-life balance (WLB) to aviation safety procedures for Air Traffic Controllers (ATCs). Both these areas have been subject to extensive research due to their implications for human performance, operational efficiency, and public safety (Kanki et al., 2010). An SLR allows for a systematic investigation of these topics by collating and analyzing evidence from diverse sources, thereby revealing commonalities, contradictions, and areas that require further exploration. This systematic approach ensures that findings are not only comprehensive but also evidence-based, providing a strong foundation for understanding WLB and safety practices within ATC contexts (Booth et al., 2012).

**FINDINGS AND DISCUSSION**

**Impact of Workload and Work-Life Balance on Aviation Safety Performance of ATC Personnel**

This section synthesizes the key findings from the systematic literature review (SLR), focusing on how workload and work-life balance (WLB) affect safety performance in the air traffic control (ATC) domain. Although international studies provide a strong theoretical foundation, a noted limitation is the absence of empirical data directly sourced from Soekarno-Hatta International Airport personnel. Nonetheless, insights from regulatory guidelines, published research, and documented incidents offer a valuable basis for analysis.

*Workload and Performance Degradation*

High workloads are consistently associated with increased stress, fatigue, and decreased operational performance in ATCs. Multiple studies (e.g., Dempsey, 2018; Kanki et al., 2010) have reported that cognitive overload leads to communication errors, slower response times, and impaired situational awareness. At Soekarno-Hatta Airport, daily aircraft movements averaged 1,216 (Hakim, 2017), with a significant concentration of up to 529 movements occurring during the morning shift. This resulted in each controller managing up to 33 aircraft per hour during peak periods, pushing the mental workload to extreme levels.

In support, the 2017 near-collision incident at Soekarno-Hatta was partly attributed to ATC fatigue and miscommunication under pressure. According to Sutrisno (2017), 28% of Soekarno-Hatta ATCs worked more than two continuous hours without a break, violating national safety regulation *Kementerian Perhubungan Republik Indonesia* (2015), which mandates a break after two hours and limits guiding hours to six per day.

*Work-Life Balance and Safety Adherence*

Well-balanced work-life arrangements contribute positively to ATC performance by improving focus, decision-making, and compliance with safety protocols. Flexibility—where

feasible—has been linked to improved health outcomes and reduced burnout (Allen et al., 2014). However, due to the continuous and safety-critical nature of ATC operations, full working-hour flexibility is not feasible. ICAO regulations demand constant monitoring and defined shift coverage, limiting adaptability in scheduling.

Instead, structured WLB practices, such as rotational shifts and mandatory rest, mitigate fatigue. For example, Soekarno-Hatta implemented a 4-days-on/2-days-off and 3-days-on/1-day-off rotating schedule (Yulenda, 2018). However, the unequal workload distribution—heavier in the morning shift—suggests the need for workload rebalancing strategies.

Eurocontrol (2018) and Cahill et al. (2020) emphasized the importance of organizational support, including fatigue risk management systems, mental health services, and peer support programs. These are particularly vital for ATCs operating in high-stress environments like Soekarno-Hatta, one of the 20 busiest airports in the world.

*Comparative Findings with Previous Research*

The results of this study align with and expand upon previous literature in the following notable ways:

1. Excessive Workload and Safety Performance: The negative relationship between excessive workload and safety performance observed in this study echoes the findings of Dempsey (2018) and Kanki et al. (2010). These studies identified cognitive overload and communication breakdowns as major issues when ATCs operate under excessive stress and fatigue. Our results further emphasize that reducing workload is imperative for minimizing human errors in safety-critical operations.
2. Benefits of Flexible Working Arrangements: The positive correlation between work-life balance and ATC performance, highlighted in this study, supports Kanki et al. (2010)'s assertion that rested ATCs are more effective and less prone to errors. This study provides additional insights by demonstrating that flexible scheduling can enhance work-life balance, leading to greater adherence to safety protocols and improved decision-making accuracy.
3. Rigid Working Structures and Individual Responsibility: The challenge posed by rigid work schedules for ATCs, as identified in this study, contrasts with findings by Eurocontrol (2018), which focused on organizational initiatives to support work-life balance. While Eurocontrol (2018) emphasized the need for structural solutions such as fatigue risk management, our results indicate that achieving work-life balance remains heavily dependent on the individual's ability to manage stress within the constraints of the industry's demanding schedule.
4. Work-Life Balance for ATC Personnel: Work-life balance contributes greatly to worker satisfaction and productivity. However, ATC work requires extra responsibility to ensure flight safety. The ATC is required to maintain work shift time to divide the workload of ATC personnel with each other. Therefore, the work-life balance mechanism is essential to divide the work portion, but the mechanism of flexibility in working hours cannot be forced to be adopted in ATC work procedures. Therefore, the work-life balance trend is not suitable for adoption in ATC work divisions (Buser & Machin, 2017).

**Table 1**. Summary of Key Findings on Work-Life Balance and Aviation Safety for ATCs

| No | Aspect | Findings from the Current Study | Comparison with Prior Research |
|---|---|---|---|
| 1 | Excessive Workload | Negative impact on safety implementation leads to increased errors and reduced situational awareness. | Supported by Dempsey (2018): Excessive workload is linked to cognitive overload and communication breakdowns. |
| 2 | Work-Life Balance Benefits | Higher concentration, accuracy, and adherence to safety protocols were observed with balanced ATCs. | Aligned with Kanki et al. (2010), well-rested ATCs exhibit improved safety and operational effectiveness. |
| 3 | Rigid Work Schedules | Structural constraints limit flexibility, assigning responsibility to individuals to maintain WLB. | Partially contradicts Eurocontrol (2018), suggesting the need for broader organizational support mechanisms. |
| 4 | Work-Life Balance for ATC Personnel | Flexibility in working hours tends to be incompatible with ATC jobs that require high responsibility. | Supported by Buser and Machin (2017), ATC roles require unique strategies that balance safety with personnel needs. |

Source: Author, 2024

The results summarized in Table 1 highlight a clear link between workload, work-life balance, and operational safety. Excessive workload impairs safety-critical behaviors, while work-life balance serves as a buffer that enhances performance. The comparison with prior research further validates these findings while highlighting differing perspectives on individual vs. organizational responsibilities for achieving balance.

**Effect of Work-Life Balance on ATC Personnel at Soekarno Hatta Airport**

On June 18, 2017, a near-collision incident occurred between two aircraft on the runway of Soekarno-Hatta Airport, Cengkareng, China. This incident attracted attention because it was strongly suspected to have been caused by ineffective communication between the parties. Several factors have influenced this condition, including radio frequency congestion, signal interference, such as sparks (interference), and errors in the pronunciation or understanding of instructions. Notably, fatigue is also one of the main causes that contribute to communication errors, both from the Air Traffic Controller (ATC) and the pilot. Fatigue is generally caused by workloads that exceed normal limits. According to Sutrisno (2017), much work-accident data shows the high contribution of fatigue to incidents in the aviation world. Therefore, fatigue management is an important aspect to prevent the risks of accidents and losses. Prevention efforts can be made by managing working hours according to regulations, providing sufficient rest time, and providing rest facilities that support physical fitness, mental balance, and psychological health of workers (Suma'mur, 1996). This aims at creating optimal operational safety.

The role of ATC assistant officers is also very important, especially when approaching peak hours for aircraft movement. Cooperation between ATC officers and assistants should be improved to anticipate fatigue experienced ahead of shift changes. Ten minutes before the change of personnel, the assistant must ensure an understanding of the ongoing tasks to take over smoothly (*Kementerian Perhubungan Republik Indonesia*, 2015). Yulenda's (2018) research showed that the

morning work shift of ATC officers at Soekarno-Hatta Airport starts at 06.00 to 14.00, day shift at 14.00 to 20.00, and night shift at 20.00 to 20.00. Night shift at 20.00 to 06.00. Each division has a different number of officers in each shift. The tower division (TWR) and APP have 38 officers each, while the ACC division has 64 officers. Officers, while the ACC division has 64 officers due to the greater responsibility and number of aircraft served. The number of aircraft to be served is also greater.

The maximum capacity of the runway is 60 movements per hour, with a minimum separation of 5 Nautical Miles (Nm) between aircraft. At times of peak movements such as Lebaran homecoming, traffic can reach 82 movements per hour, exceeding the safe capacity according to per hour, exceeding the safe capacity per the Minister of Transportation Instruction No. IM 8 Year 2017. Transportation Minister's Instruction No. IM 8 Year 2017, which sets a maximum slot of 76 movements per hour. This condition shows the potential for increased risk of fatigue for ATC officers who work more than the permitted time limit, as found by Yulenda (2018), that 28% of officers worked more than two hours without a break. By *Kementerian Perhubungan Republik Indonesia* (2015), exceeding this limit increases the risk of fatigue, resulting in reduced performance and potential accidents.

Research shows that a person's productivity tends to decrease after 4 hours of continuous work, which is associated with a drop in blood sugar levels. Therefore, a 30-minute break after 4 hours of work is essential (Medianto, 2017). Efforts to manage fatigue management efforts through shift rotation, rest periods, and good teamwork need to be improved so that ATC officers can remain teamwork need to be improved so that ATC officers can maintain concentration in carrying out their duties (Ridley, 2008). Implementation of shift work includes a work pattern of 4 working days 2 days off, and 3 working days, 1 day off, with rotation between morning, afternoon, and night shifts. This strategy aims to maintain a balance between work and rest and reduce the risk of fatigue.

Based on the research presented, there are significant challenges in maintaining work-life balance (WLB) for Air Traffic Controllers (ATC) at Soekarno-Hatta Airport. The high demands of the job, such as strict shift rotations, excessive workloads during peak hours, and the need to stay alert at all times, make flexibility in work very limited. Here are some points of analysis:

*Work Demand and Fatigue Burden*

ATCs at Soekarno-Hatta Airport work under high pressure, especially during the morning shift, which has the most aircraft movements. High pressure, especially during the morning shift, which has the most aircraft movements, reaching 529 movements per day. With strict working time standards and the need to maintain high concentration in regulating air traffic, the risk of fatigue is real. Studies have shown that 28% of ATCs work more than two consecutive hours, which exceeds the maximum work reference standard. This contributes to performance degradation and can increase the risk of operational errors that jeopardize safety

*Implementation of Working Hours and Rest Standards*

By regulations *Kementerian Perhubungan Republik Indonesia* (2015), the ATC has provisions regarding working hours, which are no more than six guiding hours per day and a minimum rest break of one hour after two hours of continuous work. These efforts aim to prevent fatigue, which affects decision-making and attention to safety procedures.

*Communication and Coordination*

The communication factor is also a critical issue, especially when radio frequency congestion or other interference occurs. Clear and effective communication between the ATC and pilots is key in ensuring flight safety. Unclear communication due to fatigue can add to the risk, as

was the case with a near-collision on the runway in 2017.

*Shift Arrangements and Team Support*

The work pattern of rotating shifts of 4 days on and 2 days off and 3 days on and 1 day off provides time for physical and mental recovery. However, the workload on certain shifts, especially mornings, requires more attention in rescheduling and team management. Time rolling and teamwork are important for maintaining this balance.

*The Importance of WLB Awareness*

ATCs should recognize that the limited flexibility of working hours is a unique characteristic of their profession, which sets them apart from other occupations. This understanding can help manage expectations and encourage adjustments to daily practices to maintain work-life balance.

To maintain work-life balance, ATC at Soekarno-Hatta Airport requires a combination of managerial strategies and self-awareness. Policies implemented to regulate working hours and rest breaks should be strengthened, along with access to wellness programs and mental support. This implementation aims to ensure that despite the stress of their jobs, ATCs can still achieve a balance that helps improve their performance and maintain flight safety.

**CONCLUSION**

This study underscores the crucial relationship between workload, work-life balance (WLB), and aviation safety performance among Air Traffic Controllers (ATCs) at Soekarno-Hatta International Airport. The findings reveal that excessive workload and inflexible scheduling contribute significantly to fatigue, stress, and the potential for human error—factors that directly threaten aviation safety. Structured WLB practices, including regulated rest periods, rotating shifts, and support from assistant controllers, offer tangible benefits in maintaining controller focus and performance.

Although the primary context of this study is Soekarno-Hatta International Airport, the findings carry broader applicability to other high-density and high-complexity airports, particularly in regions with similar operational constraints and workforce structures. The identified challenges—fatigue, cognitive overload, inflexible scheduling, and regulatory compliance—are shared across many ATC environments globally, indicating that the proposed strategies can inform international best practices through appropriate local adaptation.

Given the safety-critical nature of ATC operations, the adoption of conventional flexible working hours is not feasible. Instead, targeted interventions must operate within ICAO's regulatory framework, emphasizing consistency, vigilance and safety assurance. To achieve this, aviation authorities and airport operators should institutionalize comprehensive fatigue risk management systems, provide mental health resources and develop scheduling models that balance operational demands with human limitations.

Comprehensive fatigue risk management systems should consist of both preventive and responsive strategies. Preventive components include proactive workload monitoring, cognitive fatigue awareness training, and optimized scheduling to prevent excessive consecutive duty hours. Responsive components should feature mechanisms for real-time fatigue detection (e.g., wearable biosensors), early intervention protocols, temporary task reassignment, and post-incident debriefing procedures. These systems should be guided by data analytics and integrated into operational planning and staff performance assessments.

Mental health support must also be embedded in the ATC environment in a manner that is both effective and non-disruptive. The recommended approaches include access to on-site or

virtual professional counseling services, regular stress management workshops, peer support networks, and confidential self-assessment tools. These services should be offered outside peak hours or integrated into shift rotations to avoid operational disruption. Institutions should also cultivate an organizational culture that reduces stigma surrounding mental health and encourage ATCs to seek help proactively.

Looking ahead, future efforts should prioritize empirical research involving direct input from ATC personnel through surveys, interviews, or real-time performance monitoring. Such data would provide grounded insights into the effectiveness of existing WLB measures and identify gaps in current practices. Additionally, pilot programs testing adaptive scheduling algorithms, wearable fatigue detection technology, and digital workload tracking tools could offer scalable solutions tailored to the unique demands of air traffic control. These initiatives are essential not only to enhance ATCs' well-being but also to reinforce the broader goal of sustaining aviation safety in increasingly complex airspace environments.

## LIMITATION AND FURTHER RESEARCH

This research is primarily based on a systematic literature review, which, although comprehensive, has limitations. First, the reliance on secondary data sources means that conclusions are drawn from existing research without a primary empirical investigation specific to Soekarno-Hatta International Airport. As such, the findings depend on the quality and scope of the literature reviewed, which may not fully capture the current operational dynamics or regional nuances affecting Air Traffic Control (ATC). Due to my inability to survey the field and limited time, and position, I chose to use the SLR method. This research should have used quantitative methods using Likert scales.

Future research should aim to fill this gap through primary data collection, such as surveys or interviews with ATCs, to gain deeper insights into the unique challenges they face and their perceptions of existing WLB measures. Comparative studies across different airports and regions can also highlight the best practices and effective strategies that transcend contextual differences. In addition, exploring innovative approaches, such as technology-based fatigue monitoring systems, and evaluating their effectiveness in the real world could yield valuable insights. Expanding research to examine the long-term impact of tailored fatigue management and organizational support interventions on ATC performance and safety outcomes will contribute to more sustainable improvements in this critically important area.

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