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The Effect of Air Traffic Controller Work Stress on Decision-Making Quality in the Tower and Approach/Terminal Units of the Jakarta Air Traffic Service Center

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Abstract: T Aviation safety is strongly influenced by the performance of Air Traffic Controllers (ATC), particularly in operational decision-making. High air traffic density, time pressure, shift work, and safety responsibilities can generate work-related stress that may affect the quality of ATC decision-making. This study aims to analyze the effect of work stress on the quality of decision-making among Air Traffic Controllers at the Tower and Approach/Terminal units of the Jakarta Air Traffic Service Center (JATSC). The research employs a quantitative approach using a correlational method. The sample consists of 39 active ATC selected through purposive sampling. Data were collected using Likert-scale questionnaires measuring work stress and decision-making quality. Data analysis included validity and reliability tests, statistical assumption testing, and correlation and simple linear regression analysis. The results of this study are expected to provide empirical evidence regarding the relationship between work stress and ATC decision-making quality and to serve as an evaluation reference for air navigation service providers in improving safety performance.

Keywords: Work Stress; Decision-Making Quality; Air Traffic Controller; Aviation Safety

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Introduction

Air traffic control is a fundamental component of the civil aviation safety system. International Civil Aviation Organization (ICAO) emphasizes that air traffic services are established to prevent collisions between aircraft, maintain an orderly flow of air traffic, and support the safe and efficient conduct of flights (ICAO, 2025). Air Traffic Controllers (ATC) play a central role in achieving these objectives by providing separation, clearances, and operational instructions to aircraft operating in controlled airspace and aerodrome environments. Aviation safety is a top priority in global air transportation (Alaydi & Ng, 2024). The International Civil Aviation Organization (ICAO) emphasizes that aviation safety is influenced not only by technological reliability and procedures but also by human factors involved in flight operations (Prakoso et al., 2018). One of the key elements in the aviation safety system is the ATC, who holds a strategic role in managing, separating, and controlling air traffic.

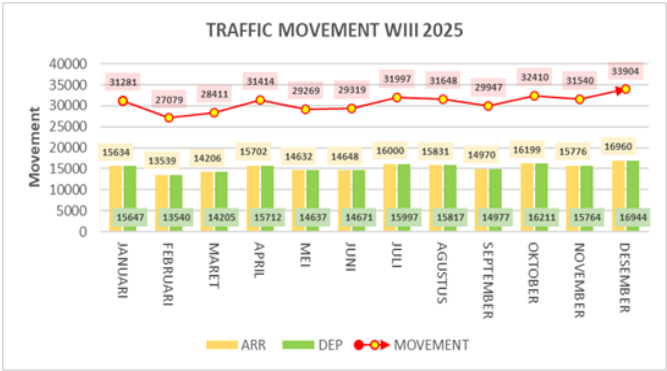

Figure 1. Monthly frequency distribution of aircraft movements in the WIII service region in 2025.

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The duties of ATC require continuous vigilance, rapid information processing, and precise decision-making in dynamic and time-critical situations. Units such as Aerodrome Control Tower (TWR) and Approach/Terminal Control Area (APP/TMA) are characterized by high traffic density, limited airspace, and intensive coordination requirements (ICAO, 2025). These operational characteristics place substantial cognitive and psychological demands on ATC, particularly during peak traffic periods and abnormal operational conditions(Suryani et al., 2023).

Operational demands faced by air traffic controllers are further reflected in the volume of air traffic movements within their service areas. As illustrated in Figure 1, the monthly distribution of aircraft movements in the WIII service region throughout 2025 demonstrates consistently high traffic density with noticeable fluctuations. Traffic volumes remained at relatively high levels throughout the year, with most months recording more than 29,000 aircraft movements. The highest traffic volume occurred in December, reaching 33,904 movements, while the lowest was recorded in February with 27,079 movements. This pattern indicates sustained operational intensity over time, suggesting continuous exposure of air traffic controllers to high workload conditions, particularly during peak traffic periods.

ICAO recognizes that aviation safety is not determined solely by technical systems and procedures but is also strongly influenced by human factors (ICAO Human Factors Digest No. 7). Among these factors, work stress has been identified as a significant element affecting human performance. Prolonged exposure to high workload, time pressure, and responsibility for flight safety can create stress conditions that challenge an individual's cognitive and emotional capacity (Russeng et al., 2021; Saleh et al., 2022).

Work stress in air traffic control is closely related to mental workload, fatigue, and environmental demands (Diah Puspitasari & Ratna Kustanti, 2018; Fadhillah et al., 2022). ATC are required to operate under shift work systems, including night shifts, which may disrupt circadian rhythms and reduce alertness (Senjaya et al., 2020). ICAO human factors studies indicate that excessive stress can negatively affect attention, situational awareness, and information processing, increasing the likelihood of human error in safety-critical operations.

Decision-making quality is a core aspect of ATC performance. According to ICAO Annex 11 and ICAO Document 4444, ATC decisions must be accurate, timely, and compliant with established procedures to ensure adequate separation and operational safety (ICAO, 2025). Human factors research suggests that stress can impair judgment and reduce the ability to evaluate operational alternatives effectively, thereby affecting the quality of decisions made under pressure (Saleh et al., 2022).

Considering the high operational demands at the Jakarta Air Traffic Service Center (JATSC), particularly in the Tower and Approach/Terminal units, it is important to understand how work stress influences ATC decision-making. This study aims to analyze the effect of work stress on the quality of decision-making among Air Traffic Controllers at JATSC. The findings are expected to contribute to human factors research in air traffic control and support safety management efforts within air navigation service providers.

Method

This study uses a quantitative research design with a correlational approach to examine the effect of work stress on decision-making quality among ATC. A quantitative method is suitable because it enables objective measurement of variables and statistical testing of relationships between them (Sugiyono, 2019).

The research was conducted at JATSC, focusing on ATC assigned to the TWR and APP/TMA units due to their high operational complexity and safety-critical functions (ICAO, 2025). The population consisted of all active ATC in these units. A purposive sampling technique was applied, resulting in 60 ATC selected based on active rating and minimum operational experience of one year (Suryani et al., 2023).

Data were collected using a Likert-scale questionnaire measuring work stress and decision-making quality. Work stress indicators were developed based on human factors theory, including workload, time pressure, fatigue, and safety responsibility (ICAO Human Factors Digest No. 7). Decision-making quality indicators were derived from ICAO Annex 11 and ICAO Doc. 4444, emphasizing accuracy, timeliness, procedural compliance, communication clarity, and situational awareness (ICAO, 2025). Data analysis included validity and reliability tests, normality testing, and correlation and simple linear regression analysis to test the research hypothesis (Qurnia Sari et al., 2017; Reza Akbar et al., 2022).

Result and Discussion

The research instruments were developed to measure several constructs using a five-point Likert scale. Workload was measured using nine items (BK1–BK9), work stress using six items (TK1–TK6), and decision-making quality using six items (KP1–KP6). In addition, SOP compliance and operational communication were measured using six items (SOP1–SOP6), while situational awareness was measured using three items (SA1–SA3). Prior to further statistical

analysis, all measurement items were subjected to validity and reliability testing to ensure that the instruments were appropriate and internally consistent for representing the research constructs.

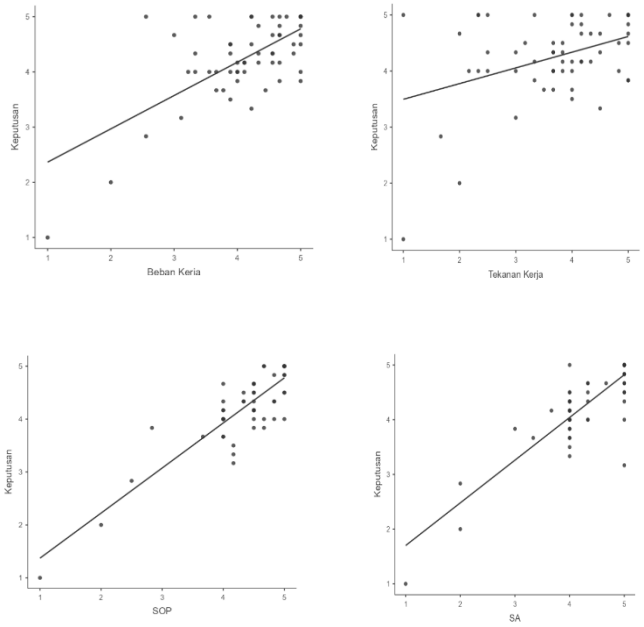

Figure 2. Scatter plots illustrating the relationships between workload, work stress, SOP compliance, situational awareness, and decision-making quality.

The results of instrument testing indicate that all variables meet the required validity and reliability criteria, with corrected item–total correlation values exceeding 0.30 and Cronbach's Alpha coefficients above 0.70. These findings confirm strong internal consistency across all constructs and support the suitability of the instruments for subsequent statistical analysis.

Before conducting inferential analysis, the assumptions for parametric testing were examined. Although the Shapiro–Wilk test indicated minor deviations from perfect normality, the sample size allowed the data to be treated as approximately normally distributed. Linearity testing using scatter plots demonstrated linear relationships between workload, work stress, SOP compliance, situational awareness, and decision-making quality, as illustrated in **Figure 2.** In addition, multicollinearity testing showed that all tolerance values exceeded 0.10 and all variance inflation factor values were below 10, indicating that no multicollinearity issues were present in the regression model.

Correlation Matrix

Correlation Matrix

		Beban Kerja	Tekanan Kerja	Keputusan	SOP	SA
Beban Kerja	Pearson's r	—				
	df	—				
	p-value	—				
Tekanan Kerja	Pearson's r	0.873 ***	—			
	df	58	—			
	p-value	< .001	—			
Keputusan	Pearson's r	0.658 ***	0.391 **	—		
	df	57	57	—		
	p-value	< .001	0.002	—		
SOP	Pearson's r	0.603 ***	0.405 **	0.865 ***	—	
	df	57	57	56	—	
	p-value	< .001	0.001	< .001	—	
SA	Pearson's r	0.552 ***	0.401 **	0.846 ***	0.899 ***	—
	df	58	58	57	57	—
	p-value	< .001	0.002	< .001	< .001	—

Note. * p < .05, ** p < .01, *** p < .001

Figure 3. Pearson correlation matrix among workload, work stress, SOP compliance, situational awareness, and decision-making quality.

Pearson correlation analysis revealed that all independent variables were positively and significantly associated with decision-making quality. As shown in **Figure 3**, workload demonstrated a strong positive correlation ($r = 0.658$, $p < 0.001$), indicating that higher workload levels, when still manageable, are associated with increased cognitive engagement. Work stress showed a moderate correlation ($r = 0.391$, $p = 0.002$), reflecting its complex relationship with performance. SOP compliance and situational awareness exhibited very strong positive correlations with decision-making quality ($r = 0.865$ and $r = 0.846$, respectively; $p < 0.001$), highlighting the critical role of procedural adherence and situational understanding in air traffic control operations.

Multiple linear regression analysis further demonstrated that workload, work stress, SOP compliance, and situational awareness collectively explained a substantial proportion of the variance in decision-making quality ($R^2 = 0.842$). The regression results presented in **Figure 4** indicate that workload had a positive and significant effect on decision-making quality ($\beta = 0.606$, $p < 0.001$), suggesting that an optimal level of workload enhances alertness and information processing. In contrast, work stress had a negative and significant effect ($\beta = -0.327$, $p < 0.001$), indicating that excessive psychological pressure impairs concentration, judgment, and cognitive flexibility.

Linear Regression

Model Fit Measures

Model	R	R^2
1	0.918	0.842

Note. Models estimated using sample size of N=58

Model Coefficients - Keputusan

Predictor	Estimate	SE	t	p
Intercept	0.184	0.2521	0.731	0.468
Beban Kerja	0.606	0.1368	4.433	< .001
Tekanan Kerja	−0.327	0.0922	−3.550	< .001
SOP	0.288	0.1340	2.151	0.036
SA	0.353	0.1189	2.966	0.005

Figure 4. Results of multiple linear regression analysis examining the effects of workload, work stress, SOP compliance, and situational awareness on decision-making quality.

SOP compliance ($\beta = 0.288$, $p = 0.036$) and situational awareness ($\beta = 0.353$, $p = 0.005$) also showed positive and significant effects on decision-making quality. These findings emphasize that adherence to standardized procedures and the ability to maintain comprehensive situational awareness serve as stabilizing factors that support accurate and timely decision-making in complex and high-risk operational environments.

Overall, the findings demonstrate that decision-making quality among air traffic controllers is shaped by the interaction of operational demands and human factors. While workload can enhance performance when appropriately managed, excessive work stress poses a clear risk to cognitive effectiveness. Strong SOP compliance and high situational awareness play a crucial role in maintaining reliable decision-making performance and supporting aviation safety.

Conclusion

This study examined the effects of workload, work stress, SOP compliance, and situational awareness on decision-making quality among air traffic controllers. The results confirm that the measurement instruments used in this study are valid and reliable, ensuring that the constructs were measured accurately and consistently. In addition, the data met the required statistical assumptions for multiple linear regression analysis, allowing the findings to be interpreted with confidence.

The results demonstrate that workload, work stress, SOP compliance, and situational awareness jointly have a significant influence on decision-making quality, explaining a substantial proportion of its variance. Partially, workload, SOP compliance, and situational awareness were found to have positive effects on decision-making quality, indicating that optimal operational demands, strong procedural adherence, and comprehensive situational understanding enhance cognitive performance. In contrast, work stress exhibited a negative effect, highlighting the detrimental impact of excessive psychological pressure on judgment and decision-making effectiveness.

These findings underscore the importance of managing both operational and human factors in air traffic control environments. Effective workload regulation, stress mitigation strategies, continuous reinforcement of SOP compliance, and the development of situational awareness are essential to support reliable decision-making and maintain aviation safety. Future research may extend this work by incorporating additional variables or employing alternative methodological approaches, such as qualitative or mixed-methods designs, to provide a more comprehensive understanding of decision-making processes in air traffic control operations.

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