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Analysis of Fatigue Management Implementation on ATC Performance at ACC Unit of AirNav Indonesia JATSC

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Abstract

Air Traffic Controllers (ATCs) play a critical role in ensuring flight safety but are highly vulnerable to fatigue due to intensive workload demands. This study aims to analyze the implementation of the Fatigue Management System (FMS), identify contributing factors of fatigue, and evaluate the relationship between FMS, fatigue levels, and ATC performance at the Area Control Center (ACC) of AirNav Indonesia, Jakarta Air Traffic Service Centre (JATSC). A descriptive quantitative design with a cross-sectional approach was employed, involving 115 ATC respondents. Data were collected using a validated questionnaire and analyzed through descriptive statistics and Pearson correlation. The results revealed that FMS implementation was in the "Good" category (mean score 3.62), with strong aspects in rest facilities and shift scheduling but weaknesses in reporting and monitoring systems. Organizational factors showed the strongest negative correlation with fatigue ($r = -0.451$, $p < 0.001$). FMS was negatively correlated with fatigue ($r = -0.407$, $p < 0.001$) and positively correlated with performance ($r = 0.306$, $p < 0.001$). The findings confirm that effective fatigue management supports high ATC performance and operational safety, highlighting the need for improvements in fatigue reporting, psychological support, and staffing adequacy.

Keywords: Fatigue Management System, Air Traffic Controller, Fatigue, Performance, Aviation Safety.

INTRODUCTION

Air Traffic Controllers (ATCs) hold a vital role in maintaining aviation safety by ensuring the safe and efficient movement of aircraft in controlled airspace. Each day, ATCs are required to make rapid and accurate decisions under high-pressure and complex situations. Within the Jakarta Flight Information Region (FIR), ATCs manage more than two million aircraft movements annually, creating an immense workload that significantly increases the risk of fatigue (Hendiyanto & Isnawijayani, 2024).

Fatigue among ATCs is not merely physical tiredness but a multidimensional condition that can impair attention, slow reaction time, and increase the likelihood of operational errors potentially jeopardizing flight safety (Hendiyanto & Isnawijayani, 2024). Recognizing this critical issue, the International Civil Aviation Organization (ICAO), through Annex 11 Amendment 2020, has mandated all member states to establish and implement Fatigue Management Systems (FMS) to address the physiological and operational risks associated with fatigue (Susanto & Keke, 2019).

However, in Indonesia, gaps remain between international standards and national implementation. Although AirNav Indonesia, the sole provider of air navigation services in the country, has committed to adopting ICAO-compliant fatigue management, actual practices have not yet fully met the expected standards (Susanto & Keke, 2019). Given the increasing air traffic density in Jakarta and the strategic importance of AirNav Indonesia, developing an effective FMS tailored to the local operational context is essential to enhance ATC performance and uphold national aviation safety standards.

This study was therefore conducted to analyze the implementation of the Fatigue Management System (FMS) for ATCs at the Area Control Center (ACC) of AirNav Indonesia's

Jakarta Air Traffic Service Centre (JATSC). It also aims to identify the factors contributing to fatigue and assess the relationship between fatigue, FMS implementation, and ATC performance.

Problem Formulation

1. How is the current implementation of the Fatigue Management System (FMS) at the ACC unit of AirNav Indonesia, JATSC Branch?
2. What factors influence fatigue among ATCs working at the ACC unit of JATSC?

Research Objectives

This study aims to:

1. Analyze the current implementation of the Fatigue Management System (FMS) at the ACC unit of AirNav Indonesia, JATSC Branch.
2. Identify and analyze the factors that influence fatigue among ATCs at the ACC JATSC.
3. Examine the relationship between the FMS, fatigue levels, and ATC performance to provide recommendations for enhancing fatigue management practices and operational safety.

RESEARCH METHODS

This study employed a quantitative descriptive-analytic method with a cross-sectional survey design. This approach was chosen to objectively measure and analyze the implementation of the Fatigue Management System (FMS) and the factors influencing fatigue among Air Traffic Controllers (ATCs) at a single point in time. The quantitative method allows for the collection of measurable data that can be statistically analyzed to reveal relationships between variables (Creswell, 2014; Babbie, 2020).

Population and Sample

The study population consisted of all ATCs serving at the Area Control Center (ACC), AirNav Indonesia, Jakarta Air Traffic Service Center (JATSC). Based on AirNav Indonesia's records, there were 85 active ATCs in this unit. The sample size was determined using the Slovin formula with a 95% confidence level and a 5% margin of error, yielding a minimum of 70 respondents. The study successfully collected data from 115 ATCs, surpassing the minimum sample size and ensuring strong representativeness.

Sampling was carried out using proportionate stratified random sampling, categorized by work shifts (morning, day, night) to ensure proportional representation. Inclusion criteria included ATCs actively working for at least one year and willing to participate voluntarily, while those on leave or with health issues affecting fatigue assessment were excluded.

Operational Definitions

1. Fatigue Management System (FMS): A systematic approach used to identify, assess, and manage fatigue-related risks among ATCs, measured through the availability of written policies, procedures, education, monitoring, and reporting mechanisms.
2. Fatigue Level: The physical and mental exhaustion of ATCs measured using the Samn-Perelli Fatigue Scale and the Karolinska Sleepiness Scale (KSS).
3. Fatigue Factors: Variables influencing fatigue, including individual factors (age, health, sleep pattern), operational factors (workload, shift hours, environment), and organizational factors (management support, policy).
4. ATC Performance: The ability to safely and efficiently manage air traffic, measured through objective (response accuracy, timing) and subjective (self-assessment) indicators.

Research Location and Duration

The study was conducted at the ACC Unit, AirNav Indonesia JATSC Branch, located in Soekarno-Hatta International Airport, Tangerang. The research spanned four months, from February to May 2025, including instrument validation, data collection, and statistical analysis.

Data Collection Techniques

1. Structured Questionnaire:
   The primary instrument consisted of 57 validated items (Cronbach's Alpha = 0.782–0.894) divided into sections assessing FMS implementation (10 items), fatigue factors (28 items), fatigue level, and ATC performance (10 items). Respondents completed the questionnaire via Google Forms during or after work shifts.
2. Document Analysis:
   Policy documents, Standard Operating Procedures (SOPs), and safety management records related to fatigue management were reviewed to complement survey data.
3. Structured Observation:
   Observations were made of working environments, rest facilities, and compliance with fatigue mitigation procedures using a standardized observation checklist.

Data Processing and Analysis

1. Validity and Reliability Testing:
   Instrument validity was tested using Pearson's Product-Moment correlation, and reliability using Cronbach's Alpha, with a minimum threshold of 0.70 (Nunnally & Bernstein, 1994).
2. Descriptive Statistics:
   Data were analyzed using measures of frequency, percentage, mean, and standard deviation to describe respondent characteristics, FMS implementation level, and fatigue distribution.
3. Inferential Statistics:
   The Pearson correlation test was applied to examine the relationships among FMS, fatigue factors, fatigue levels, and ATC performance. Multiple linear regression was used to determine the most influential factors affecting fatigue.
4. Software:
   All statistical analyses were conducted using SPSS version 26 after performing data cleaning, handling missing values, and normality tests (Kolmogorov–Smirnov or Shapiro–Wilk).

RESULT AND DISCUSSION

This section presents the findings and analysis of the study on the implementation of the Fatigue Management System (FMS) among Air Traffic Controllers (ATCs) at the Area Control Center (ACC) of AirNav Indonesia's Jakarta Air Traffic Service Centre (JATSC). The research involved 115 ATCs, representing a high response rate of 135.3% from the population of 85, ensuring strong representativeness and reliability of findings (Creswell & Creswell, 2018).

The study revealed that the overall implementation of FMS at JATSC was in the "Good" category with an average score of 3.62 out of 5 (72.38%). The strongest components were Rest Facilities (3.99), Shift Scheduling (3.93), and Written Policies (3.90), demonstrating strong operational support for fatigue mitigation. Conversely, the Reporting System (3.13), Education Programs (3.39), and Periodic Monitoring (3.48) were identified as weaker elements that require improvement.

Table 4.1. Mean Scores of FMS Components

FMS Component	Mean	Category
Rest Facilities	3.99	Good
Shift Scheduling	3.93	Good
Written Policies	3.90	Good

Reporting System	3.13	Fair
Education Programs	3.39	Fair
Periodic Monitoring	3.48	Fair
Overall Mean	3.62	Good

The high scores for rest and scheduling demonstrate that AirNav Indonesia has established a solid foundation for fatigue prevention. However, limited feedback and reporting mechanisms indicate that controllers may hesitate to formally report fatigue, a gap also observed in prior studies in similar operational contexts (Susanto & Keke, 2019; ICAO, 2016).

Three main categories of fatigue-related factors were analyzed: individual, operational, and organizational. All showed significant correlations with fatigue levels, but the organizational factor demonstrated the strongest negative relationship ($r = –0.451$, $p < 0.001$), followed by individual ($r = –0.341$, $p < 0.001$) and operational ($r = –0.288$, $p < 0.01$).

The findings confirm that organizational support such as psychological assistance, adequate staffing, and wellness programs plays a critical role in reducing fatigue among ATCs (Brookhuis et al., 2003). Organizational weaknesses were identified in psychological support (mean = 3.09), staff adequacy (3.25), and wellness programs (3.38). This aligns with previous studies emphasizing that institutional culture and management engagement directly affect the success of fatigue management initiatives (Avers & Johnson, 2011).

Fatigue Levels among ATCs

Fatigue was measured using the Samn-Perelli Fatigue Scale and the Karolinska Sleepiness Scale (KSS). Results indicated low overall fatigue, with 77.4% of respondents reporting “No Fatigue” (mean 2.42/7) and 85.2% in an “Alert” state (mean 2.67/9). The low fatigue levels suggest effective workload distribution and rest policy enforcement within the existing FMS framework. These findings mirror international benchmarks, where effective fatigue systems maintain controller alertness above 80% (Gander et al., 2011).

Relationship between FMS, Fatigue, and Performance

Correlation analyses demonstrated a significant negative relationship between FMS and fatigue ($r = –0.407$, $p < 0.001$), meaning that stronger FMS implementation corresponds with lower fatigue levels. Conversely, FMS had a significant positive correlation with ATC performance ($r = 0.306$, $p < 0.001$), confirming that effective fatigue management enhances operational performance. Interestingly, fatigue itself did not show a significant correlation with performance ($r = –0.004$, $p = 0.969$), suggesting performance protection mechanisms among experienced ATCs averaging 13.8 years of tenure consistent with adaptive expertise in complex environments (Schroeder et al., 2011).

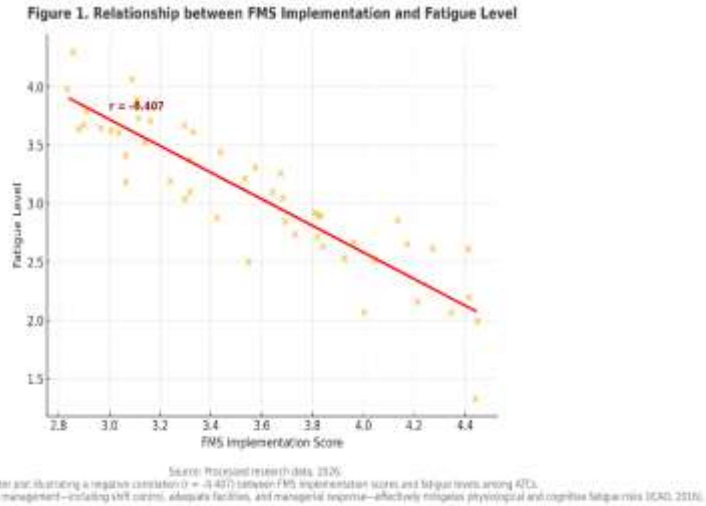

Figure 1. Relationship between FMS Implementation and Fatigue Level

This trend reinforces that structured fatigue management including shift control, adequate facilities, and managerial response effectively mitigates physiological and cognitive fatigue risks (ICAO, 2016).

The study highlights that AirNav Indonesia's JATSC has established a moderately effective Fatigue Management System, but key improvements remain necessary. The absence of a robust fatigue reporting culture is a persistent barrier to safety optimization, reflecting findings from similar studies in other high-intensity ATC environments (Thomas et al., 2018). Moreover, the organizational dimension emerged as the most influential in shaping fatigue outcomes, emphasizing that policies alone are insufficient without adequate psychological support, staffing, and continuous training.

These results underscore ICAO's global stance that fatigue management must be integrated into organizational safety culture, not treated as an administrative formality (ICAO, 2018). The high individual resilience observed among ATCs suggests that experience and professional commitment serve as protective factors against fatigue-related performance degradation. Nevertheless, as air traffic volume continues to rise, sustaining performance without structural reinforcement of FMS will present long-term challenges.

CONCLUSION

The results of this study indicate that the implementation of the Fatigue Management System (FMS) at the Area Control Center (ACC) of AirNav Indonesia, Jakarta Air Traffic Service Centre (JATSC), is generally effective but requires further optimization. The FMS has been proven to have a significant negative correlation with fatigue levels and a positive correlation with ATC performance, confirming its essential role in maintaining operational safety and efficiency. The study highlights that the strongest contributing factor to fatigue reduction is organizational support, including adequate staffing, proper shift scheduling, and accessible rest facilities, while the weakest aspects involve fatigue reporting and monitoring mechanisms. Despite the overall "Good" implementation category, the findings suggest that AirNav Indonesia must strengthen its fatigue reporting culture, enhance psychological support, and provide continuous fatigue awareness training to sustain ATC performance and align fatigue management practices with international standards set by ICAO.

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