The Influence of Working Hours Duration on the Fatigue Level of ATC Personnel in the Approach Control Procedural Unit in Banjarmasin, Indonesia

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ABSTRACT
This article analyzed the effect of working hours on the fatigue level of Air Traffic Controller (ATC) personnel in the Approach Control Procedural unit at Syamsudin Noor International Airport, Banjarmasin. The research's background highlights the vital role of ATC in ensuring flight safety, where long working hours can lead to fatigue, decreased alertness, and circadian rhythm disturbances, ultimately increasing the risk of incidents. Therefore, this study aimed to measure the impact of working hours on fatigue and identify related factors. The research used a descriptive quantitative approach. A total of 20 ATC personnel were selected as the sample using a census sampling technique. Primary data was collected through questionnaires with a Likert scale and then analyzed using SPSS to test for validity, reliability, normality, simple linear regression, Pearson's correlation, and a T-test. The results show a significant and positive effect of working hours on the fatigue level of ATC personnel. The simple linear regression analysis yielded a regression coefficient of 0.864 with a significance value of 0.002 ($p < 0.05$), indicating that an increase in working hours significantly raises fatigue levels.

Keywords: *" Working Hours, Air Traffic Controller (ATC), Approach Control Procedural, Flight Safety "*

1. INTRODUCTION

The modern aviation industry, with all its complexity and dynamics, rests upon a foundation that ensures safety, order, and efficiency in the movement of air traffic. This foundation is Air Traffic Services (ATS), operated by highly qualified personnel known as Air Traffic Controllers (ATC). ATCs are often referred to as the "backbone of modern aviation safety" (Susanto, 2020), a role that demands extraordinary responsibility as it involves safeguarding thousands of lives every single day. Without their presence, the airspace would become a chaotic and high-risk environment (Luh et al., 2022).

The fundamental duties of an ATC personnel are summarized in five main objectives: to prevent collisions between aircraft both in the air and on the ground, to expedite and maintain the orderly flow of air traffic, to provide crucial information and advice for flight safety, and to notify relevant organizations if an aircraft requires assistance and search and rescue. Within this complex ecosystem, there are various units with different task specializations, one of which is the Approach Control Procedural (APP) unit, which plays a vital role in the critical phases of flight (Luh et al., 2022).

The Approach Control Procedural (APP) unit is responsible for guiding aircraft transitioning from the en-route phase to the landing phase at the destination airport, as well as monitoring aircraft that have just departed until they reach their initial cruising altitude. This position places APP personnel in the midst of high-density traffic within relatively limited airspace, requiring them to simultaneously manage various speed profiles, altitudes, and flight directions. The cognitive demands inherent in this task are extremely high, involving sustained concentration, split-second decision-making, and the processing of large volumes of information.

This condition inherently creates a significant mental workload, which has been identified as one of the major sources of stress in the ATC profession (imam et al.,

2024). The workload becomes even heavier in a procedural environment. Unlike radar-based operations, which provide real-time visualization of air traffic, the Approach Control Procedural unit operates without such support. ATC personnel must rely on verbal position reports from pilots, data from flight progress strips, and, most importantly, the construction and continuous maintenance of an accurate four-dimensional mental model of each aircraft's position in their minds. This absolute reliance on cognitive functions such as working memory, spatial reasoning, and sustained attention drastically amplifies mental workload. Within this context, a paradox arises: despite advancements in aviation technology, procedural environments place the greatest cognitive burden directly on human operators. Consequently, the cognitive state of ATC personnel itself becomes the most critical—and most vulnerable—defense for aviation safety (Holley & Miller, 2022).

Aviation safety is a crucial, non-negotiable aspect of the global air transport industry (Silvia, 2021). Behind every safe and smooth flight lies the vital role of Air Traffic Controllers (ATC), who bear full responsibility for managing the movement of aircraft both on the ground and in the air. The duties carried out by ATCs, especially within the Approach Control Procedural (APP) unit, demand an exceptionally high level of concentration, accuracy, and vigilance. The dynamic work environment, time pressure, and immense responsibility make ATC personnel highly vulnerable to fatigue.

Previous studies have shown that fatigue can significantly impair cognitive performance, slow reaction times, and increase the risk of human error, which may ultimately endanger aviation safety. At Syamsudin Noor International Airport, Banjarmasin, the APP unit faces similar challenges as air traffic volume continues to increase. Long working hours and strict shift patterns have the potential to be major factors contributing to ATC personnel fatigue.

Therefore, this research aims to conduct an in-depth analysis of the influence of working hours duration on the fatigue levels of Air Traffic Controllers in the APP unit at Syamsudin Noor International Airport, Banjarmasin. The results of this study are expected to provide meaningful contributions to the formulation of more optimal work-hour management policies, ensuring both aviation operational safety and the well-being of ATC personnel.

In procedural environments, ATC personnel are especially vulnerable to fatigue. While workload is an inherent factor of the job, the exposure duration to such workload—namely working hours—is a variable that can be adjusted and managed. Recent studies consistently show a significant relationship between working hours, shift schedules, and levels of fatigue and occupational stress among ATC personnel and similar professions (Pascasarjana & Hasanuddin, 2015).

In high-demand work environments, there exists the risk of a "normalization of workload," where conditions that actually represent precursors to fatigue are perceived as a normal part of the job. This normalization may mask the onset of chronic fatigue, which accumulates gradually and only becomes evident after the occurrence of an incident.

Thus, this research seeks to deeply analyze the influence of working hours duration on the fatigue levels experienced by ATC personnel in the Approach Control Procedural unit. By understanding this causal relationship, evidence-based recommendations can be formulated for optimizing work schedules and implementing effective fatigue mitigation strategies, thereby safeguarding the cognitive resilience of ATC personnel and ensuring the highest level of aviation safety.

1.1. Definition Of Work Fatigue

Occupational fatigue is broadly defined as a decline in process efficiency, work performance, and physical fitness to continue an activity, functioning as a defense mechanism of the body to prevent damage. More specifically, occupational fatigue is a characteristic of excessive workload and reflects a limited capacity to meet job demands (Watterson et al., 2023). This fatigue represents a biological drive to obtain restorative rest (P & Prastawa, 2023)

1.2. Types Of Work Fatigue

Fatigue can be categorized based on various aspects. From the perspective of muscular processes, fatigue can be classified into general fatigue and muscle fatigue. Based on its causes, fatigue can be divided into psychological fatigue, which arises from factors such as job coercion or a chaotic work environment, and physiological fatigue, which emerges from environmental conditions such as humidity or noise. In terms of its occurrence over time, fatigue may be chronic, persisting continuously, or acute, resulting from excessive work or physical exertion beyond one's limits (P & Prastawa, 2023).

The literature further distinguishes the dimensions of fatigue into mental, emotional, and physical fatigue (Canadian Centre for Occupational Health and Safety, 2024). Mental fatigue manifests as reduced mental capacity, lack of attention, and difficulty in decision-making. Physical fatigue involves weakness or physiological degradation. Meanwhile, subjective fatigue encompasses feelings of tiredness, drowsiness, or lethargy (Watterson et al., 2023).

1.3. Factors That Cause Fatigue

Fatigue may arise from a combination of various factors, both internal and external (Juliana et al., 2018). Internal factors include age, anemia status, length of service, sleep quality, workload, gender, nutrition, and lifestyle. External factors consist of shift work patterns, hot working climates, environmental conditions (e.g., lighting, noise), biological factors (e.g., viruses), chemical factors (e.g., hazardous substances), and ergonomic factors. Monotonous or repetitive tasks can also intensify feelings of fatigue. For ATC personnel, workload, situational awareness, and vigilance are critical factors which, when disrupted, may negatively affect performance (P & Prastawa, 2023).

1.4. Impact of Excessive Working Hours

Prolonged working hours, irregular shift patterns (especially night shifts), and inadequate rest periods have consistently been identified as major contributors to fatigue among workers, including ATC personnel. Working more than 8 hours per day significantly increases the risk of fatigue (European Union Aviation Safety Agency, 2025). Specifically, respondents engaged in overtime were found to have a 3.130 times greater risk of experiencing occupational fatigue (Chang, Yu-Yang, Hui-HuHsu, 2019).

Night shifts, in particular, are associated with higher levels of fatigue compared to day shifts, especially during the Window of Circadian Low (WOCL)—the circadian trough period occurring between approximately 02:00–05:59 a.m. Shorter sleep duration prior to a night shift further exacerbates sleep pressure and decreases alertness. Irregular shift patterns, such as quick returns (intervals of less than 11 hours between consecutive shifts), are known to trigger fatigue and reduce overall sleep duration (Maximilian Peukert 1, Lea Claus 2, 2025). Counter-clockwise shift rotations have also been linked to increased fatigue and diminished cognitive performance (Peukert & Meyer, 2022).

1.5. The Role of Circadian Rhythms and Sleep Deficit in ATC Fatigue

The human body operates according to the circadian rhythm, a 24-hour sleep/wake cycle that is naturally programmed for rest during nighttime hours (Canadian Centre for Occupational Health and Safety, 2024). Demanding work schedules can disrupt this natural cycle, leading to increased fatigue, stress, and reduced concentration. Shift work, particularly night shifts, interferes with the circadian rhythm, resulting in difficulty obtaining restorative sleep and decreased performance while awake. The body cannot permanently adapt to a reversed work–sleep cycle, as often occurs in shift work (Peukert & Meyer, 2022).

1.6. Empirical Findings from Studies Related to Work Duration in ATC

Research consistently shows that fatigue among ATC personnel is strongly associated with shift work and time-related factors (Maximilian Peukert, Lea Claus, 2025). Studies have identified significant differences in fatigue levels between day and night shifts as well as across various work schedules (Miriam Bongo, 2021). Sleep duration prior to a shift is significantly shorter before night shifts, leading to increased sleep pressure and reduced alertness during the Window of Circadian Low (WOCL) (Chang, Yu-Yang, Hui-HuHsu, 2019). Subjective fatigue tends to increase toward the end of night shifts, clearly reflecting circadian influences. Empirical evidence also indicates that ATC fatigue increases after six hours of duty and with extended working hours.

However, nuanced findings should be noted: a study on computer users (non-ATC) found that although working hours did not directly affect concentration levels, occupational fatigue had a significant impact on it (Rosdiana, 2019). Conversely, another study on construction workers explicitly revealed a “relationship between working time and fatigue” (Syaputra & Lestari, 2019). This highlights the complexity of the relationship and the potential for variation across different professions or study methodologies. For ATC personnel, given their high cognitive demands, the link between long working hours, fatigue, and cognitive performance remains a critical concern.

2. METHODS

This study employs a quantitative method with a descriptive approach. This approach was chosen to systematically analyze and describe the influence of working hours duration on the fatigue levels of personnel in the APP unit. The focus of this research is to collect numerical data from ATC personnel in the APP unit to identify and measure the extent to which internal and external factors contribute to occupational fatigue.

2.1. *Type of Research*

This research applies a quantitative analytical design. The quantitative approach was selected to statistically measure and analyze the relationship between working hours duration and fatigue levels among Air Traffic Controller (ATC) personnel. The purpose of this study is to test hypotheses and generalize findings to a wider population, in line with previous studies investigating the relationship between working hours and fatigue using quantitative methods (Syaputra & Lestari, 2019).

2.2. *Research Design*

The design employed is cross-sectional, which allows for data collection on working hours duration and

fatigue levels simultaneously at a specific point in time. This design is suitable for identifying the prevalence of fatigue and its relationship with working hours duration among ATC personnel in the Approach Control Procedural Unit. While this design cannot establish a definitive causal relationship, it is effective in identifying correlations and existing patterns (Rosidina, 2019).

2.3. Research Location

This study will be conducted in the Approach Control Procedural (APP) Unit at Syamsudin Noor International Airport, Banjarmasin. The location was selected based on the specific focus of the research, which targets ATC personnel in this unit and airport.

2.4. Research Subjects

The subjects of this study are all Air Traffic Controllers (ATC) serving in the Approach Control Procedural Unit at Syamsudin Noor International Airport, Banjarmasin. The population includes all ATC personnel meeting the inclusion criteria (e.g., minimum working period, not currently on extended leave or illness). Sampling will use a total population technique if feasible, or a saturated sample method if the population is relatively small, to ensure comprehensive representation of the study group.

2.5. Data Collection Techniques

Data collection will involve observation (direct monitoring) and questionnaires.

a. The questionnaire is designed based on relevant indicators, such as working duration, frequency of night shifts, and levels of physical and mental fatigue.
b. The use of questionnaires enables efficient and structured data collection from respondents.
c. The type of questionnaire employed will be multiple-choice, where respondents are provided with four alternative answers and required to select one (Silvia, 2021).

2.6. Data Analysis Techniques

Data will be analyzed using SPSS version 29, with the following steps:

a. Validity Test: An instrument is considered valid if it measures what it is intended to measure. This ensures accuracy and alignment between the instrument and the research objectives (Fattimah, 2024).
b. Reliability Test: An instrument is reliable if repeated measurements of the same object produce consistent results. Reliability emphasizes stability and consistency across time. Cronbach's Alpha will be applied to assess reliability (Fahmi, 2019).
c. Simple Linear Regression: Used to analyze the relationship between two variables, i.e., the independent variable (working hours duration) and the dependent variable (fatigue level) (Nuryadi et al., 2017).
d. Pearson Correlation Test: Conducted to assess the strength and direction of a linear relationship between two continuous variables (Cahyaningsih, 2021).
e. T-Test: Applied to determine whether there are significant mean differences between two groups.

2.7. Validity and Reliability of Data

To ensure validity and reliability, the following measures will be taken:

a. Instrument Validity: Questionnaires will be adapted from previous studies with proven validity and reliability in similar populations. If new instruments are developed or adapted, validity testing (e.g., content validity, construct validity) and reliability testing (e.g., Cronbach's Alpha) will be conducted (Aurelia, 2024).
b. Data Triangulation: Combining subjective and objective methods will strengthen data accuracy and comprehensiveness while mitigating the limitations of each method (Larissa Carvalho,Sarah Francisca De Souza Borges, 2021).

Conclusion of Research Methodology

This chapter presents a detailed and systematic methodological framework designed to comprehensively investigate the relationship between the duration of working hours and the fatigue levels of Air Traffic Controllers (ATCs). The study focuses specifically on the Approach Control Procedural Unit at Syamsudin Noor International Airport, Banjarmasin.

To ensure the scientific rigor and validity of our findings, this research employs a quantitative cross-sectional design. This approach allows us to collect data on both working hours and fatigue levels at a single point in time, enabling us to analyze their correlation. We integrate both subjective and objective data collection techniques to achieve a holistic understanding of the issue. Subjective data, gathered through questionnaires, captures the personal perceptions and experiences of the ATC personnel regarding their fatigue. Simultaneously, objective data, collected from operational logbooks and other records, provides concrete evidence of working hour patterns.

The application of appropriate statistical analyses is crucial for interpreting these data accurately. We will utilize simple linear regression analysis to determine if there is a direct influence of working hours on fatigue and to quantify the strength of this relationship. Furthermore, the use of reliability and validity tests will ensure that our

measurement instruments are consistent and truly measure the intended concepts.

Adherence to research ethics is paramount throughout this study. We will ensure the confidentiality and anonymity of all participants and obtain their informed consent. By following these rigorous procedures, this research aims to produce not only valid and reliable findings but also to maintain the highest level of scientific integrity. The practical relevance of the results will directly support the development of effective fatigue mitigation strategies, ultimately contributing to the enhancement of aviation safety at Syamsudin Noor International Airport.

3.RESEARCH AND RESULTS

3.1. Observation

The author conducted observations from January 1 to January 31, 2025. The author conducted field observations regarding the effect of working hours on the Fatigue level of Air Traffic Controller personnel while the author was conducting On-the-Job Training (OJT) in the Approach Control Procedural unit at Syamsudin Noor International Airport, Banjarmasin.

The following is an example of an Air Traffic Controller personnel duty schedule at the Banjarmasin Branch:

Figure 3. 1 Airnav Banjarmasin Branch ATC Service Schedule

From the schedule above, there are 3 shifts in one day: morning, afternoon, and night. The morning shift is from 9:30 PM to 5:30 AM UTC, the afternoon shift from 5:00 AM to 10:30 AM UTC, and the night shift from 10:00 AM to 3:00 PM UTC. There are 2 ATC personnel on duty per shift. The author observed the performance of Air Traffic Controller personnel during rush hour (working hours). The author chose rush hour (working hours) because that is when there is often a surge in aircraft traffic at the Approach Control Procedural Unit.

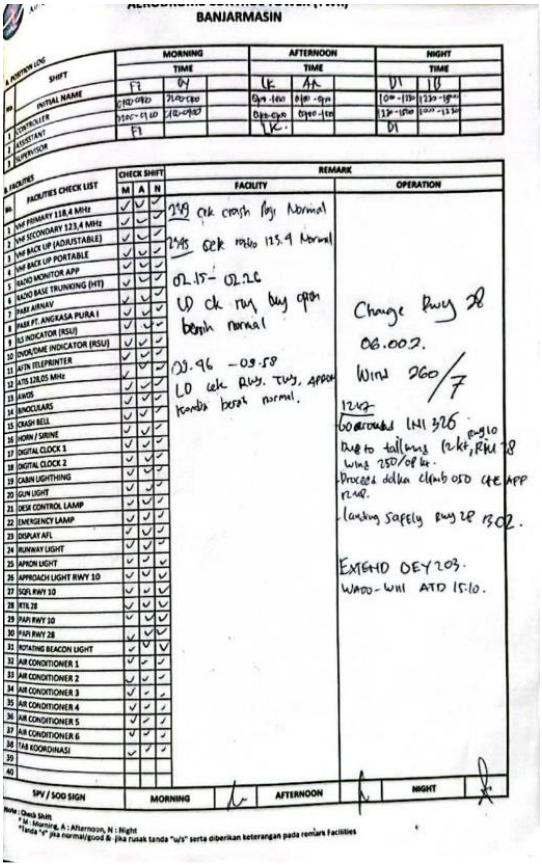

Figure 3. 2 Banjarmasin ATC Daily Log Book

This image displays a daily operational worksheet used by Air Traffic Controller (ATC) personnel to log activities, equipment status, and significant events during a work shift. When ATC personnel are providing services, several things need to be considered, namely the important factors related to the duration of working hours. Long working hours and high workload can impact the personnel's fatigue levels, which in turn can affect their concentration, decision-making accuracy, and speed in responding to operational situations. Therefore, it's crucial to examine the extent to which working hours influence the fatigue level of ATC personnel at Syamsudin Noor International Airport, Banjarmasin, to ensure air traffic services remain optimal, safe, and efficient.

The expectation from this observation is that it can provide results showing that working hours have a significant influence on the fatigue level of Air Traffic Controller personnel in the Approach Control Procedural unit. The fatigue experienced by personnel can lead to a decrease in performance, which can indirectly affect aviation operational safety. This aims to maintain the safety, efficiency, and smooth flow of air traffic at Syamsudin Noor International Airport, Banjarmasin.

3.2. Questionnaire

A questionnaire is a list containing a series of questions about a specific problem or topic being studied, with the aim of obtaining data in the form of opinions or perceptions from research subjects. In this study, the questionnaire was used as the primary instrument to collect data regarding the influence of working hours on the fatigue level of Air Traffic Controller personnel in the Approach Control Procedural unit.

There are two main variables in this study: working hours as the independent variable and fatigue level as the dependent variable. Each variable has problem indicators obtained from field observations and relevant theories and references on the factors of work fatigue in Air Traffic Controller personnel.

Based on the indicators for each variable, the researcher created one type of questionnaire, namely a questionnaire on working hours and a questionnaire on work fatigue levels, each consisting of 10 statements. This questionnaire contained both positive (favorable) and negative (unfavorable) statements to get more objective answers from the respondents.

The questionnaire was distributed on June 12, 2025, and given directly to the respondents, who are the Air Traffic Controller personnel working in the Approach Control Procedural unit at Syamsudin Noor International Airport, Banjarmasin. Each respondent was only allowed to give one response for each statement by marking the answer choice that matched their experienced condition. In the data collection process, the questionnaire was distributed directly by the researcher to the respondents using Google Forms. The respondents in this study were Air Traffic Controller personnel working in the Approach Control Procedural unit at Syamsudin Noor International Airport, Banjarmasin. The researcher also took care to choose the right time to distribute the questionnaire, selecting personnel who were not busy or had a break, so that the questionnaire could be filled out with more focus and the results would reflect the true conditions as accurately as possible.

The questions in the questionnaire were accompanied by multiple-choice answers measured using a Likert scale with a range of 1 to 4. According to (Sugiyono, 2017), a Likert scale is used to measure a person's or a group's attitudes, perceptions, and opinions about a social phenomenon. In the context of this research, the questionnaire used is an instrument for measuring attitudes that refers to the Likert scale parameters to find out the perceptions of Air Traffic Controller personnel towards working hours and the fatigue levels they experience. The answer choices were categorized as follows: SS (Sangat Setuju/Strongly Agree), S (Setuju/Agree), TS (Tidak Setuju/Disagree), and STS (Sangat Tidak Setuju/Strongly Disagree).

This discussion will provide a detailed account of the research findings and link them to the research questions, theoretical frameworks, and relevant prior studies.

3.3. The Influence of Working Hours on Air Traffic Controller Fatigue Levels

The main research question of this study is: "How does the duration of working hours affect the fatigue level of Air Traffic Control personnel in the Approach Control Procedural unit at Syamsudin Noor International Airport, Banjarmasin?"

Based on the results of the simple linear regression analysis and hypothesis testing, it can be concluded that working hours have a positive and significant influence on the fatigue level of ATC personnel. The positive regression coefficient (0.864) clearly shows that an increase in working hours leads to an increase in fatigue levels. This means the longer an ATC officer works, the more likely they are to experience fatigue.

This interpretation is highly consistent with the concept of work fatigue explained by Grandjean, who stated that fatigue is a condition that arises from continuous activity, characterized by a feeling of tiredness and a decrease in work output. In the context of ATC, this job demands high concentration and quick decision-making, so long working hours will accelerate the onset of fatigue. These findings are also supported by the theory of Ulandari et al. (2024), which asserts that working for prolonged durations tends to cause fatigue, health problems, and even accidents. The daily ATC logbook showing go-around incidents due to personnel fatigue is empirical evidence from the field that strengthens this relationship.

This research is also in line with previous studies by Ivan Yusri et al. (2024), who found that working hours exceeding regulations are significantly related to an increased level of fatigue among ATC personnel. Although regulations like the Manual of Standard Part 69-01 and the Technical and Professional Manual IFATCA have set limits on working hours to prevent fatigue, these findings imply that on-the-ground implementation may still have loopholes that allow personnel to experience fatigue due to what they perceive as excessive working hours. This is reinforced by the fact that the average total working hours for ATC personnel in the Approach Control Procedural unit is 140 hours/month, which, although within weekly limits, can accumulate into significant fatigue in some cases.

3.4. The Strength and Contribution of Working Hours to Fatigue

The results of the Pearson correlation test show a very strong relationship ($r = 0.673$) between working

hours and fatigue levels. This figure indicates that both variables move in the same direction and with substantial strength. This means that a change in working hours has a clear and measurable impact on the level of fatigue experienced by personnel.

However, the coefficient of determination (R2=0.453) also reveals that working hours only explain 45.3% of the variation in fatigue levels. This means that more than half (54.7%) of the variation in ATC personnel fatigue is influenced by other factors besides working hours. These factors, as identified in the questionnaire and observations, include workload, inadequate rest periods, and environmental working conditions. This indicates that ATC personnel fatigue is a multifactorial phenomenon, not solely caused by the duration of working hours.

This interpretation is important because it leads to a more holistic understanding of ATC fatigue. Suma'mur's (2019) theory of work fatigue also mentions various causes of fatigue such as work shifts, workload, physical working ecological conditions (temperature, noise, lighting), age, nutritional status, and psychological factors. These findings are consistent with that view, showing that while working hours are a significant contributor, other factors also play a crucial role. Previous research by (Nurhaliza et al., 2022) which showed that workload and working environment significantly affect ATC safety performance, and a study by (Noer Adiba Senjaya et al., 2020) which linked mental workload and working hours to human error, further strengthens the argument that fatigue is the result of an interaction of various variables.

In conclusion, to answer the research objective, it can be stated that working hours indeed have a significant and strong influence on the fatigue levels of ATC personnel. However, addressing this fatigue must be comprehensive, not only focusing on working hours but also considering other factors such as workload, rest periods, and the working environment. This discussion points to the importance of implementing a more effective Fatigue Risk Management System (FRMS) and adjusting work shift policies that consider all aspects contributing to fatigue to maintain the safety and operational efficiency of flights at Syamsudin Noor International Airport, Banjarmasin.

4. FIGURES AND TABLES

4.1. Validity Test

A reliability test is performed to assess the consistency and stability of a measurement instrument. An instrument is considered reliable if it yields consistent results when used repeatedly on the same or different subjects. In this study, the reliability test was conducted to ensure that the questionnaire on fatigue could provide stable and dependable results.

To measure the internal consistency of an instrument (like a Likert scale questionnaire), the most common method is the Cronbach's Alpha coefficient (α). This coefficient essentially reflects the average inter-item correlation within a scale, as noted by (Huberman, 2013). Cronbach's Alpha is used to indicate the level of dependability, accuracy, precision, and consistency of the items within a questionnaire. This test is typically done after any invalid items have been removed from the instrument (Huberman, 2013).

Some research fields suggest a stricter threshold, such as $\alpha>0.70$, for an instrument to be considered to have good reliability. An unreliable instrument indicates that its items are not consistently measuring the same concept, and therefore, it needs to be revised or redeveloped (Iii & Penelitian, 2022).

VARIABEL	INDIKATOR	OUTER LOADING	VALIDITY
Durasi Jam Kerja	Persepsi Durasi Shift Kerja	0,788	Valid
	Dampak Durasi Kerja terhadap Konsentrasi	0,788	Valid
	Pengaruh Durasi Kerja terhadap Kewaspadaan	0,926	Valid
	Dampak Durasi Kerja pada Kecepatan Pengambilan Keputusan	0,926	Valid
	Pengaruh Durasi Kerja terhadap Tingkat Stres	0,926	Valid
	Dampak Durasi Kerja terhadap Rasa Cemas	0,756	Valid
	Pengaruh Durasi Kerja terhadap Motivasi	0,926	Valid
	Dampak Durasi Kerja pada Interaksi Sosial	0,690	Valid
	Pengaruh Durasi Kerja terhadap Pola Tidur	0,756	Valid
	Dampak Durasi Kerja terhadap Kondisi Fisik	0,471	Valid
Tingkat Kelelahan	Dampak pada Kesehatan Mental	0,772	Valid
	Motivasi Kerja	0,733	Valid
	Keselamatan Penerbangan	0,449	Valid
	Kemampuan Multitasking	0,683	Valid
	Manajemen Stres	0,683	Valid
	Kemampuan Komunikasi	0,857	Valid
	Kerja Tim	0,602	Valid
	Manajemen Waktu	0,890	Valid
	Inisiatif dalam Bekerja	0,890	Valid
	Kemampuan Belajar dan Berkembang	0,875	Valid

Figure 3. 3 Validity Test

Based on the image above, the test results show that the instrument used is valid and reliable for this study.

4.2. Reliability Test

Reliability testing aims to assess the consistency and stability of a measurement instrument. If an instrument is tested repeatedly on the same or different subjects, the results obtained should be consistent. In this study, a reliability test ensures that the fatigue questionnaire can provide stable and dependable results. To measure the internal consistency reliability of an instrument (for example, a questionnaire with a Likert scale), the most common method used is Cronbach's Alpha coefficient (α). This coefficient essentially reflects the average inter-item correlation within a scale (Huberman, 2013). Cronbach's Alpha is used to show the level of reliability, accuracy, precision, and consistency

of the indicators (items) in a questionnaire. This test is performed after invalid items have been removed from the instrument (Huberman, 2013). Some stricter research fields or methodological guidelines suggest a higher threshold, for example, α >0.70, to be considered to have good reliability. An unreliable instrument indicates that its items are not consistent in measuring the same construct, so it needs to be revised or redeveloped (Iii & Penelitian, 2022).

Reliability Statistics

Cronbach's Alpha	N of Items
.929	10

Figure 3. 4 Reliability test results for variable x

Based on the reliability test results for variable X, the research instrument is declared reliable. This means the questionnaire or measurement tool used for this variable is consistent and dependable. One common method used to measure reliability is Cronbach's Alpha (α). This coefficient measures the internal consistency of the instrument, which is the extent to which the items in the questionnaire collectively measure the same construct. Generally, a high Cronbach's Alpha value (typically above 0.70) indicates that the instrument has good reliability.

Reliability Statistics

Cronbach's Alpha	N of Items
.913	10

Figure 3. 5 Reliability test results for variable y

Based on the reliability test results for variable Y, the research instrument is declared reliable. This means the questionnaire or measurement tool used for this variable is consistent and dependable. One common method used to measure reliability is Cronbach's Alpha (α). This coefficient measures the internal consistency of the instrument, which is the extent to which the items in the questionnaire collectively measure the same construct. Generally, a high Cronbach's Alpha value (typically above 0.70) indicates that the instrument has good reliability.

4.3. Simple Linear Regression Test

As defined by Sugiyono, simple regression analysis is based on the functional or causal relationship between one independent variable (X) and one dependent variable (Y). Its main objective is to find the best-fit linear model or equation that can be used to forecast or predict the value of the dependent variable (Y) based on the known value of the independent variable (X) (Huberman, 2013). A simple linear regression test is a statistical method used to analyze the relationship between a single independent variable (variable X) and a single dependent variable (variable Y). Its purpose is to predict the value of the dependent variable based on the value of the independent variable. In this study, this test is used to determine whether working hours (the independent variable) have an influence on fatigue levels (the dependent variable).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.479	7.258		.066	.948
	Durasi Jam Kerja	.864	.230	.673	3.750	.002

a. Dependent Variable: Tingkat Kelelahan Personel Air Traffic Controller

Figure 3. 6 Simple linear regression test results

The results of the simple linear regression test show a regression coefficient (b) of 0.864, which indicates that every one-unit increase in working hours will increase the fatigue level by 0.864 units.

4.4. Correlation Test (Pearson)

In this study, the Pearson correlation test was used to determine the strength of the relationship between working hours and the personnel's fatigue levels.

Correlations

		Durasi Jam Kerja	Tingkat Kelelahan Personel Air Traffic Controller
Durasi Jam Kerja	Pearson Correlation	1	.673**
	Sig. (1-tailed)		<.001
	N	19	19
Tingkat Kelelahan Personel Air Traffic Controller	Pearson Correlation	.673**	1
	Sig. (1-tailed)	<.001	
	N	19	19

**. Correlation is significant at the 0.01 level (1-tailed).

Figure 3. 7 Pearson correlation test results

The results of the Pearson correlation test show a coefficient (r) of 0.673, which indicates a strong and positive relationship between the two variables. This means that as one variable increases, the other variable also tends to increase. In this context, it suggests that as working hours increase, the level of fatigue also tends to increase.

4.5. Uji T

The t-test is used to determine whether a single independent variable has a significant partial effect on the dependent variable. In the context of regression, the t-test is used to test the significance of the regression coefficients.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.479	7.258		.066	.948
	Durasi Jam Kerja	.864	.230	.673	3.750	.002

a. Dependent Variable: Tingkat Kelelahan Personel Air Traffic Controller

Figure 3. 8 T test results

This test compares the p-value with a significance threshold (α). If the p-value is less than α (e.g., 0.05), it is concluded that the independent variable has a significant effect. Conversely, if the p-value is greater than α, the effect is considered not significant. In this study, the significance value obtained is 0.002 ($p < 0.05$), which confirms that the effect of working hours on fatigue is statistically significant.

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We hope that the results of this study can make a real contribution to the safety and operational efficiency of aviation and serve as a basis for further studies on the well-being of aviation personnel.

6.CONCLUTION

Based on all the analyses and discussions that have been conducted, it can be concluded that this study successfully proves a significant and strong influence between working hours and the fatigue level of Air Traffic Controller (ATC) personnel. This finding affirms the importance of giving serious attention to the factor of working hours as a key determinant of fatigue, which in turn can have a direct impact on aviation operational safety.

However, this study also highlights that fatigue is a multifactorial phenomenon, where working hours only explain part of the variation in fatigue that occurs. Therefore, future fatigue mitigation measures must not only focus on regulating working hours but also consider other factors such as workload, rest management, and environmental conditions.

Thus, the results of this study are expected to serve as a basis for relevant parties, especially the management at Syamsudin Noor International Airport, Banjarmasin, to formulate a more comprehensive policy in managing the risk of fatigue among ATC personnel. The implementation of an effective Fatigue Risk Management System (FRMS) is key to maintaining optimal personnel performance, ensuring flight safety, and supporting operational sustainability.

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