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The Development of a Work Stress Model for Air Traffic Controllers in Indonesia

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Abstract

The workload complexity experienced by and expected air traffic controllers (ATCs) causes psychological fatigue, engenders stressful conditions, and affects their quality of life. This study investigated the development of a model of psychological fatigue in ATCs in Indonesia, which affected their work stress levels and quality of life. This cross-sectional, three-month study focused on 185 ATCs randomly selected from six AirNavs based on strata. The results indicated a relationship between work duration (p-value = 0.033) and stress on ATCs; additionally, a relationship between work time and the opportunity to meet personal life needs (p-value = 0.007) were found. Feelings of tiredness among ATCs manifested as a 'thirsty throat' feeling, and in saturation measurements, no respondents had experienced hypoxia in the two months of observation. Structural equation modeling showed that psychological fatigue had no direct effect on the quality of life; however, it had an indirect and significant effect on work stress (p-value = 0.001). It can be concluded that the stress conditions experienced by the ATCs have a palpable effect on feelings of fatigue and quality of life.

Keywords: air traffic control, fatigue, psychological, quality of life, work stress

Introduction

Workers' fatigue is a significant problem in modern organizations. It also acts as a 'final signal' of the integration of waking time in a day and the workload that one carries out daily.[1,2] Theoretically, the onset of this condition is characterized by increased anxiety, memory loss, attenuations in work efficiency and vigilance, poor motivation, high variability in performance, and negligence.[3] It is challenging for employers to identify and respond to the signs of worker fatigue—not to mention psychological disorders stemming from it—which can lead to both weak work productivity and reduced quality of life.[4]

One profession that especially requires the maintenance of psychological health to ensure optimal work performance is an air traffic controller (ATC).[5] The ATC duties generate tension, especially during the critical decision-making process over aviation traffic control.[6-10] Given that 55% of worldwide aircraft accidents are caused by human error—and that this number is 60.71% in Indonesia, with ATCs accounting for 5% due to incidence (e.g., miscommunication),[11,12]—the importance of sound psychological health in this profession cannot be overstated.

The effect of psychological disturbance on ATCs is captivating because its amelioration is material to improving job performance. Furthermore, no study has concurrently examined ATCs in Indonesia and several AirNav branches (which have three strata) to identify the causes of work fatigue generally; this is concerting, considering that Indonesia has one of the busiest airports in Asia.[13] The International Air Transport Association (IATA) predicts that by 2036, Indonesia will become the world's fourth-largest air travel market and have an estimated 355 million passengers flying from and within the country in 2034. This predicted growth runs in tandem with Indonesia's promotion of airline-based tourism as something that is for everyone.[13-15]

When energy is depleted, individuals feel tired and sleepy, leading to severe stress conditions of fatigue. Likewise, most controllers experience mental fatigue due to the stress of tasks and responsibilities when making decisions that are important to flight safety, leading to psychological impairments. So, psychological fatigue among ATCs must be addressed everywhere as urgently as possible, especially in Indonesia, which is predicted to become one of the world's largest air travel hubs.[13] Therefore, this study aimed to develop a model of psychological fatigue to help ease ATC work stress, whi-

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ch impacted their quality of life and work performance.

Method

This was a cross-sectional study, and leveraged data from six AirNavs, selected on the basis of strata; those from the Main (Makassar Air Traffic Service Center /MATSC), Intermediate (AirNav Denpasar and AirNav Surabaya), and Pratama (AirNav Kupang, AirNav Lombok, and AirNav Bandung) branches. Data collection was carried out on six selected AirNav branches with the help of previously trained enumerators from their respective regions. Data were collected by interviewing each ATC about occupational stress. A questionnaire was measured feelings concerning work fatigue (*Kuesioner Alat Ukur Perasaan Kelelahan Kerja/*KAUPK2), and considering tensimeter, oximeter, and Quality of Life World Health Organization (QOL–WHO) measures. The authors validated and calibrated all instruments before undertaking the study.

The data was collected on individual identity (age, gender, and service years), health status (pulse, blood–oxygen levels, and blood pressure), productivity, work fatigue symptoms, and the ATC's quality of life. It was collected between January and June 2020 and performed sampling using proportional stratified random sampling. The total sample comprised 185 randomly selected ATCs.

The data was collected by interviewing each ATC and using occupational stress instruments. A detailed data collection process followed this: (1) Data on respondent characteristics (name, gender, years of service, and employee age) were obtained through a questionnaire and direct interviews with ATCs and pertained to the six study areas; (2) Data on health status were conducted using several health measurements, including the measurement of blood–oxygen levels, pulse, and blood pressure (diastolic and systolic). Blood–oxygen levels and pulse were measured using an oximeter. Blood pressure was measured using a tensimeter. All authors underwent training on using these tools before going into the field. Blood pressure was assessed according to the Joint National Committee on Prevention Detection, Evaluation, and Treatment of High-Pressure VIII, and pulse was assessed as per Price and Wilson (2012). Finally, the blood–oxygen level was assessed based on World Health Organization (WHO) categories (2011); (3) Data on employee productivity. These data were obtained by calculating the amount of traffic controlled by each ATC over one month and attendance and the duration/length of work of that employee over that month. The criteria for work duration were based on Regulation of the General Civil Aviation No. KP 218 of 2017. Total traffic was divided into three categories based on quartile data calculations; (4) Data on feelings of work fatigue. These data were obtained using the Questionnaire for the Measure of Work Fatigue/*Kuesioner Alat Ukur Perasaan Kelelahan Kerja* (KAUPK2), which consists of 17 items on feelings related to fatigue. This instrument was prepared by Lientje Setyawati in 1994, and its validity and reliability have been verified. This parameter measures the feeling of work fatigue as a subjective symptom, in this case among ATCs. Previously, this questionnaire also tested the validity and reliability of ATC employees, who were not respondents. The results obtained were valid and reliable; (5) Data related to work stress. These data were captured via the Occupational Stress and Well-Being among Prison Educators Questionnaire compiled by Gail Kinman and Siobhan Wray in 2013 of the University and College Union, London. This instrument consisted of 47 questions, including the number of sick days, leaves, and a scale of ideal work and personal living conditions. Previously, this questionnaire also tested the validity and reliability of ATC employees, who were not respondents. The results obtained were valid and reliable. Based on quartile data calculations, work stress was divided into three categories: high, moderate, and low stress; and (6) Data related to the quality of life. These data were obtained via the WHO–QOL–BREF questionnaire, compiled in 2004. This instrument consisted of 26 questions across four domains. This instrument was used to determine it each month the quality of life among ATCs, divided into three categories based on quartile data calculations—namely, high, medium, and low.

Having in hand data about individual identity (age, gender, and years of service), health status (pulse, blood–oxygen levels, and blood pressure), productivity, symptoms of work fatigue, and ATC quality of life, a master table in MS Excel was created. The SPSS and AMOS were the software used to analyze these data and determine the effects among the variables, and all were studied using the structural equation modeling (SEM) method.

Results

The results of this study (Table 1) found that among individuals who met the work duration requirements, 82, 51, and 40 ATCs were under high, moderate, and low levels of stress, respectively, all with a significant work duration factor. Additionally, a relationship between work duration (p-value = 0.033) and psychological factors in the form of ATC stress was found; responded to the degree or scale of the separation of work time and personal life indicated a relationship between work time and the opportunity to carry out personal life needs (p-value = 0.007). However, this work-life imbalance triggered stressful conditions that impinged upon the quality of these two factors. This finding aligns with the quality of life assessment of physical, psychological, and social relationships.

Among the participating ATCs, individual identity

Table 1. Test of Significance: Air Traffic Controller Observation Variables

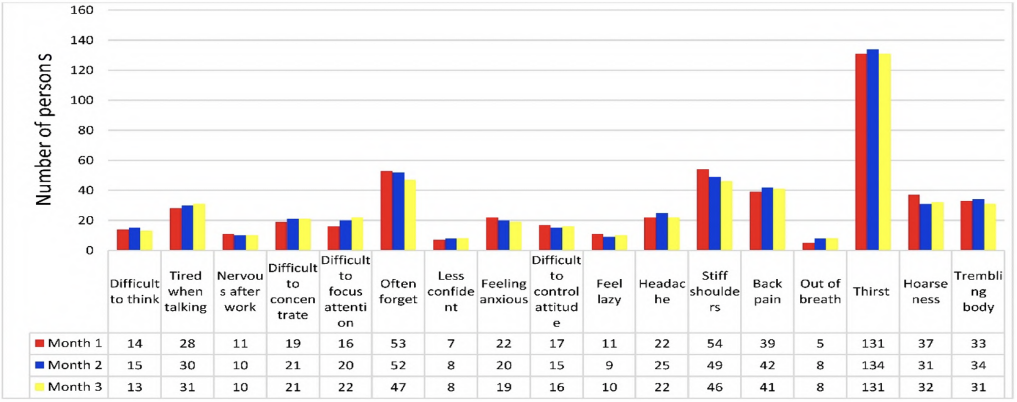
Variable	Category	High Stress	Moderate Stress	Low Stress	p-value
Gender	Female	29 (33.0%)	13 (25.5%)	18 (39.1%)	0.354
	Male	59 (67.0%)	38 (74.5%)	28 (60.9%)	
Age	≥35 years	35 (39.8%)	17 (33.3%)	18 (39.1%)	0.736
	<35 years	53 (60.2%)	34 (66.7%)	28 (60.9%)	
Years of service	≤5 years (new)	31 (35.2%)	19 (37.3%)	14 (30.4%)	0.768
	>5 years (old)	57 (64.8%)	32 (62.7%)	32 (69.6%)	
Pulse (per minute)	High	6 (6.8%)	3 (5.9%)	1 (2.2%)	0.684
	Low	4 (4.5%)	1 (2.0%)	1 (2.2%)	
	Normal	78 (88.6%)	47 (92.2%)	44 (95.7%)	
Blood–oxygen level	Hypoxia	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.575
	Low	1 (1.1%)	0 (0.0%)	0 (0.0%)	
	Normal	87 (98.9%)	51 (100%)	46 (100%)	
Blood pressure	Hypertension	2 (2.3%)	2 (3.9%)	2 (4.3%)	0.567
	Prehypertension	42 (47.7%)	28 (54.9%)	18 (39.1%)	
	Normal	44 (50.0%)	21 (41.2%)	26 (56.5%)	
Productivity	High	37 (42.0%)	22 (43.1%)	16 (34.8%)	
	Moderate	26 (29.5%)	19 (37.3%)	18 (39.1%)	0.639
	Low	25 (28.4%)	10 (19.6%)	12 (26.1%)	
Attendance	Sufficient	19 (21.6%)	8 (15.7%)	5 (10.9%)	0.279
	Good	69 (78.4%)	43 (84.3%)	41 (89.1%)	
Duration of work	Not eligible	6 (6.8%)	0 (0.0%)	6 (13.0%)	0.033
	Qualify	82 (93.2%)	51 (100%)	40 (87.0%)	
The scale of separation: work time and personal life	1	1 (1.1%)	1 (2.0%)	1 (2.2%)	
	2	2 (2.3%)	5 (9.8%)	3 (6.5%)	
	3	6 (6.8%)	2 (3.9%)	3 (6.5%)	
	4	3 (3.4%)	2 (3.9%)	0 (0.0%)	
	5	18 (20.5%)	15 (29.4%)	7 (15.2%)	0.007
	6	18 (20.5%)	3 (5.9%)	2 (4.3%)	
	7	21 (23.9%)	12 (23.5%)	10 (21.7%)	
	8	17 (19.3%)	5 (9.8%)	9 (19.6%)	
	9	88 (2.3%)	6 (11.8%)	11 (23.9%)	
Quality of life: Domain I	Low	22 (25.0%)	24 (47.1%)	39 (84.8%)	
	Medium	25 (28.4%)	19 (37.3%)	4 (8.7%)	
	High	41 (46.6%)	8 (15.7%)	3 (6.5%)	
Domain II	Low	21 (23.9%)	20 (39.2%)	31 (67.4%)	0.001
	Medium	18 (20.5%)	9 (17.6%)	8 (17.4%)	
	High	49 (55.7%)	22 (43.1%)	7 (15.2%)	
Domain III	Low	12 (13.6%)	10 (19.6%)	24 (52.2%)	
	Medium	54 (61.4%)	28 (54.9%)	19 (41.3%)	
	High	22 (25.0%)	13 (25.5%)	3 (6.5%)	
Domain IV	Low	31 (35.2%)	28 (54.9%)	38 (82.6%)	
	Medium	24 (27.3%)	18 (35.3%)	6 (13.0%)	
	High	33 (37.5%)	5 (9.8%)	2 (4.3%)	

(age, gender, and service years), health status (measurement of pulse per minute, blood–oxygen levels, and blood pressure), and productivity were found to have no relationship with the level of stress experienced. Observations vis-à-vis the ATCs' feelings of fatigue (Figure 1) show that over the three consecutive study months, the most common complaint was 'thirsty throat,' from 131, 134, and 131 respondents.

Figure 2 compares the vital signs of ATCs in months 1 and 2. No respondent was found to have experienced hypoxia (e.g., tissue-level oxygen deprivation) during that observation. Of 1.1% of respondents in the AirNav Makassar had experienced a low saturation level, and all others elsewhere had experienced none. In month 2, the saturation level was again found to be low (e.g., 20% of those in the AirNav Bandung had experienced low saturation, and all others elsewhere had experienced none) (Figure 2).

In examining health status (Month 1), it could be seen that 6.7% (2.2%) of the respondents in Makassar had a high (low) pulse rate; in AirNav Bandung, 20% of participants had a low pulse. In Month 2, 6.7% (3.4%) of those at AirNav Makassar had a high (low) pulse rate; at AirNav Denpasar, these numbers were 9.1% and 3%, respectively. At AirNav Surabaya, 7.9% of the respondents had a low pulse rate.

Based on blood pressure measurements (Month 1), it can be determined that 3.4% (44.9%) of the participants at AirNav Makassar had hypertension (prehypertension). At AirNav Lombok, 12.5% (12.5%) of participants had



	Difficult to think	Tired when talking	Nervous after work	Difficult to concentrate	Difficult to focus attention	Often forget	Less confident	Feeling anxious	Difficult to control attitude	Feel lazy	Headache	Stiff shoulders	Back pain	Out of breath	Thirst	Hoarseness	Trembling body
Month 1	14	28	11	19	16	53	7	22	17	11	22	54	39	5	131	37	33
Month 2	15	30	10	21	20	52	8	20	15	9	25	49	42	8	134	31	34
Month 3	13	31	10	21	22	47	8	19	16	10	22	46	41	8	131	32	31

Figure 1. Distribution of Feelings of Fatigue among Air Traffic Controllers in the Six Study Areas

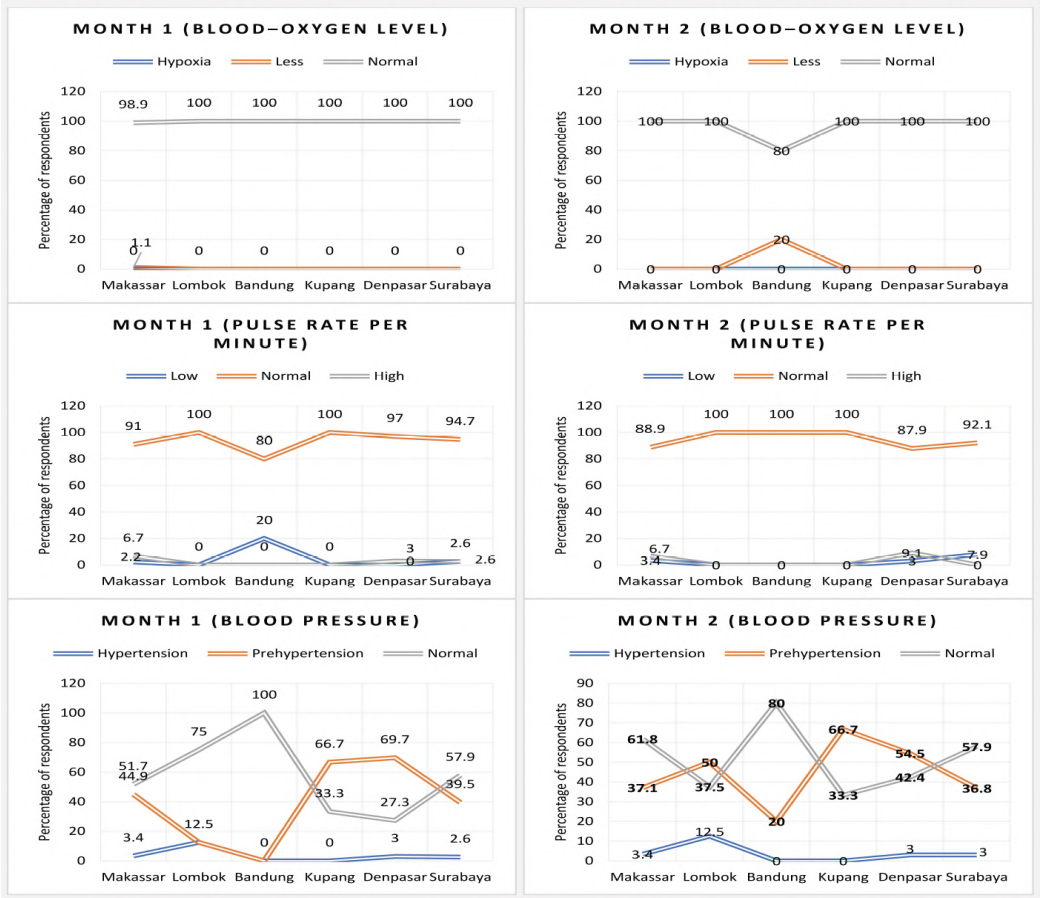


Figure 2. Comparisons of Air Traffic Controllers' Vital Signs (Months 1 and 2)

hypertension (prehypertension), while at AirNav Kupang, 66.7% of participants had prehypertension. At AirNav Denpasar, 69.7% of patients had prehypertension. At AirNav Surabaya, 2.6% (39.5%) had hypertension (prehypertension); in the second month, 3.4% (37.1%) had hypertension (prehypertension). In AirNav Lombok, 12.5% (50%) had hypertension (prehypertension), while in AirNav Bandung (AirNav Kupang), 20% (66.7%) had prehypertension. At AirNav Denpasar, 3% (54.5%) had hypertension (prehypertension), while at AirNav Surabaya, 3% (36.8%) had hypertension (prehypertension).

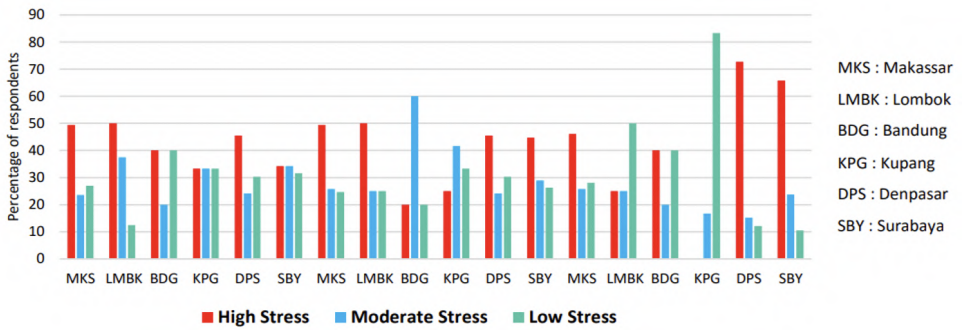
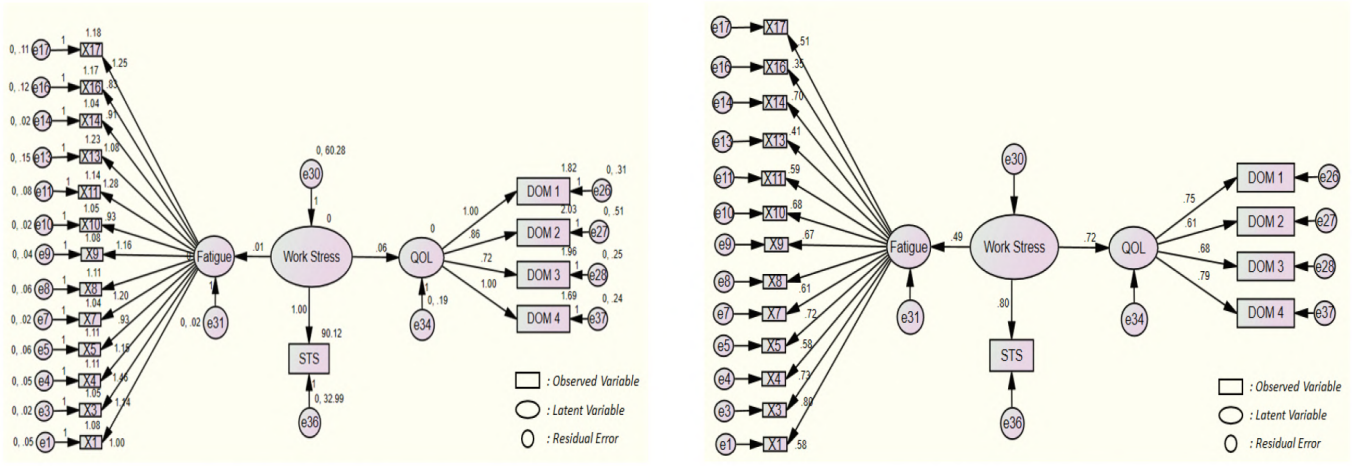


Figure 3. Stress Levels by AirNav Branch in Indonesia (Percent)



Unstandardized Estimates **Standardized Estimates**

Notes: QOL = Quality of Life, STS = Stress, DOM = Domain, X1 = Difficult to think, X3 = Nervous after work, X4 = Difficult to concentrate, X5 = Difficult to focus attention, X7 = Less confident, X8 = Feeling anxious, X9 = Difficult to control attitude, X10 = Feel lazy, X11 = Headache, X13 = Back pain, X14 = Out of breath, X16 = Hoarseness, X17 = Trembling body.

Figure 4. Work Stress Model of Air Traffic Controllers in Indonesia

ATCs at AirNav Surabaya generally experienced stress in Months 1–3, with 34.2%, 44.7%, and 65.8% of participants reporting low, medium, and high-stress levels, respectively. Those at AirNav Denpasar experienced stagnant stress levels in Months 1 and 2 (45.5% each), but in Month 3, that facility recorded the highest high-stress prevalence level (72.7%) (Figure 3).

Based on SEM analysis (Figure 4), the authors found that the stress conditions experienced by the ATCs correlated with fatigue and quality of life: the higher the work stress that causes fatigue, the more it affects ATC quality of life. With each unit of work, stress increases in psychological fatigue (by 0.49) and quality of life (by 0.72).

Based on p-values, the authors found correlations between work stress and quality of life (p-value = 0.001) and feelings of psychological fatigue (p-value = 0.001) to be significant. The psychological fatigue variables were significant for all fatigue indicators (X1–X17 inclusive; p-value = 0.001); similarly, the quality of life variable was significant for all ATC indicators (Domains I–IV inclusive; p-value = 0.001). In addition, the work variables were significant stress indicators (p-value = 0.001) (Table 2, Figure 4).

Discussion

Based on the finding of this study, it was found that while the participating ATCs had good physical health status, they tended to experience poor mental health due to high levels of work pressure. This condition occurs because as air traffic increases, the perceived workload also increases. According to Zhang,[16] the emergence of

Table 2. Results of Structural Equation Modelling Test Analysis

Variable			p-value
Quality of life	<---	Work stress	0.001
Feelings of fatigue	<---	Work stress	0.001
X1	<---	Feelings of fatigue	0.001
X3	<---	Feelings of fatigue	0.001
X4	<---	Feelings of fatigue	0.001
X5	<---	Feelings of fatigue	0.001
X7	<---	Feelings of fatigue	0.001
X8	<---	Feelings of fatigue	0.001
X9	<---	Feelings of fatigue	0.001
X10	<---	Feelings of fatigue	0.001
X11	<---	Feelings of fatigue	0.001
X13	<---	Feelings of fatigue	0.001
X14	<---	Feelings of fatigue	0.001
X16	<---	Feelings of fatigue	0.001
X17	<---	Feelings of fatigue	0.001
Domain I	<---	Quality of life	0.001
Domain II	<---	Quality of life	0.001
Domain III	<---	Quality of life	0.001
Domain IV	<---	Quality of life	0.001
Stress	<---	Work stress	0.001

Notes: X1 = Difficult to think, X3 = Nervous after work, X4 = Difficult to concentrate, X5 = Difficult to focus attention, X7 = Less confident, X8 = Feeling anxious, X9 = Difficult to control attitude, X10 = Feel lazy, X11 = Headache, X13 = Back pain, X14 = Out of breath, X16 = Hoarseness, X17 = Trembling body.

fatigue and stressful conditions interferes with control performance. Fatigue causes ATCs to work more slowly and pay less attention to controlled air traffic situations. This challenge requires ATCs to remain physically and mentally healthy to maintain optimal vigilance. Previous studies also highlight the sources of fatigue among controller officers, both physically and mentally, including the tools used, workloads, work shifts/patterns, traffic, climate, and self-efficacy.[17-25]

The authors found the degree of health to have no correlation with stress. Those findings were insignificance of the hypothesis in research conducted on ATCs related to the standard health inspection system, especially vital signs that are routinely observed. Health controls should be assessed for ATCs at least every six months, and the responsibility of ensuring compliance rests with the employer.[26] The health check system at AirNav is routinely carried out at least every six months so that problems with the health status variable are not a stressor.

The results of the proposed SEM test (Figure 4) show that work stress increases psychological fatigue among ATCs. This result stems from the fact that stress—prompted by various internal and external stressors—is channeled through the nervous system. These stressors activate the glands that produce within the brain the hormones cortisol and adrenaline; these hormones then work together to activate the sympathetic nervous system and ultimately increase the heart rate, control the sweat glands, and make the muscles work more.[27,28] Given the nature of their work demands, ATCs continuously carry out their duties with high intensity, and this triggers factors that result in fatigue. In Indonesia, the ATC profession carries high social and economic status levels in terms of both income and lifestyle. In addition, AirNav Indonesia also monitors ATC health, provides facilities that support ATCs' work, and works to mitigate the risk of occupational illness and accidents.[29] These initiatives increase ATC job satisfaction and, in turn, positively impact their quality of life.

For each problem that ATCs experience, factors need to be resolved in real terms, based on real data; stress-prevalence levels and other results will vary depending on the research methods used. It was found that various psychological factors had adverse effects, though not all stress was unfavorable: there were also positives that ATCs needed to keep moving forward.[30] Some stress requiring intervention was experienced at the individual level,[31] and manifested as depressive conditions. Such issues must be pre-empted through early stress management strategies. The long-term effects of stress contribute to memory loss, gastric ulcers, colitis, musculoskeletal disorders, hypertension, heart disease, cancer development, and death.[32] Work stress was also a potential mediator of low quality of life and negatively impinges upon work performance and productivity.[33-35] Raga,[36] stated that four ATCs at Chicago O'Hare International Airport have died from sudden cardiac events and two from pancreatic cancer. Many others have suffered from stress-related gastrointestinal diseases. These results provided evidence of the extent of mental disorders among ATCs. So it is necessary to provide interventions in the form of routine relaxation, which has an effect similar to that of exercise, in that it stabilizes organ functions.[37]

The provision of relaxation as a control for psychological fatigue among ATCs in Indonesia could reduce the impact of the stress they experience, helping them live healthy, safe, and efficient lives, both at work and home. The findings of this study align with Saleh's,[37] who found a significant difference in work stress between pre- and posttests in the intervention group ($z = -2670$, p-value = 0.008). There was also a significant reduction in work stress following relaxation therapy. Therefore, progressive muscle relaxation techniques are recommended for patients experiencing anxiety, depression, stress, headaches, insomnia, fatigue, muscle spasms, and hypertension.[38]

One advantage inherent in this study design is that the data collection was undertaken three times in three months, thus allowing for comparisons in the respondents' conditions. Another advantage is that this study considers many variables. So the causes of various psychological conditions can be seen from several per-

spectives, including health status, work fatigue, quality of life, and work stress. This study, like any other study, does have weaknesses and limitations. It uses a cross-sectional study design to make no conclusions regarding causality. However, the results of this study can inform future research and act as a reference point in investigating other variables related to psychological fatigue among ATCs.

One possible bias inherent in this study may derive from the lack of guidance given to participants as they executed the questionnaire. The questionnaire was sufficiently long that its execution could have led to boredom and thus hasty or careless answers. This challenge can be overcome by providing questionnaire assistance or conducting interviews with all respondents when collecting data.

Conclusion

In conclusion, stress conditions among air traffic controllers directly affect feelings of fatigue and quality of life. Therefore, organizations and related parties within the aviation sector need to work together to mediate stress experienced by employees and problems deriving from that stress. It is recommended that future researchers measure work stress, feelings of fatigue, and quality of life by adding several variables such as sleep quality, work environment, and work organization, and by using other measuring instruments such as cocorometers and reaction timers.

Abbreviations

ATC: Air Traffic Controller; IATA: International Air Transport Association; IATCA: Indonesia Air Traffic Controller Association; MATSC: Makassar Air Traffic Service Center; KAUPK2: *Kuesioner Alat Ukur Perasaan Kelelahan Kerja*; QOL–WHO: Quality of Life – World Health Organization; SEM: Structural Equation Modeling; WHO: World Health Organization.

Ethics Approval and Consent to Participate

The study was approved by the Research Ethics Committee of Hasanuddin University (Approval ID No. 91018065007).

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance.

Availability of Data and Materials

The research data are not publicly available, containing the participants' private information.

Authors' Contribution

LMS, SSR, and IT conceptualized and designed the study and interpreted the data. IHY and NMS prepared the study framework and the initial draft. MY and YR analyzed the data and proofread the manuscript.

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