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RESEARCH ARTICLE

Analysis of Work Productivity Through Work Fatigue in Aircraft Engineers at Sultan Hasanuddin Airport Makassar in 2024

Dian Eka Putri[1*], Lalu Muhammad Saleh[2], Furqaan Naiem[3], Syamsiar S. Russeng[4], Fridawaty Rivai[5]

[1,2,3,4] Department of Occupational Health and Safety, Faculty of Public Health, Hasanuddin University, Makassar Indonesia, Institution
[5] Department of Hospital Management, Faculty of Public Health, Hasanuddin University, Makassar Indonesia, Institution

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***Corresponding Author:**

dianekaputri799@gmail.com

ABSTRACT

The working environment of aircraft engineers features non-stop 24-hour working hours, highly diverse and changing working conditions and situations, and demands that can result in poor sleep quality and extremely high workloads. This leads to fatigue, which can reduce work productivity and increase the likelihood of human error that can affect safety. Objectives: The study aims to determine the direct effect of physical workload, mental workload, noise, sleep quality, and job stress on work productivity and its indirect effect through job fatigue on Aircraft Engineer PT. GMF AeroAsia at Sultan Hasanuddin Airport Makassar in 2024. This study used a mix method (explanatory sequential design) with 72 aircraft engineers of PT. GMF AeroAsia at Sultan Hasanuddin Airport Makassar and 8 informants. There is an indirect effect of sleep quality (p=0.038) and work stress (p=0.035) on work productivity through fatigue. There is a direct influence of physical workload (p=0.000) and mental workload (p=0.000) on work productivity. Meanwhile, noise has no influence either directly (p=0.297) or indirectly (p=0.167). This study found that sleep quality and work stress have an influence that is partial mediation. Mental workload and physical workload were found to have a non-mediation effect, while noise had no effect on work productivity.

INTRODUCTION

It is estimated that the number of air passengers in Indonesia will increase by 30% per year to 140 million in a few years, so that Indonesia could become the world's top six air transportation market by 2034 (Ministry of Industry of the Republic of Indonesia, 2022). The number of aircraft until 2022 according to (Central Statistics Agency Of The Republic Of Indonesia, 2023) is 1096 units which are registered aircraft that have air transportation operator certification. The need for aircraft technicians continues to increase in proportion to the increasing use of aircraft. The aviation industry operates 24 hours nonstop requiring technicians to have a busy work schedule, so they must always be ready and able to solve existing problems within a very limited time limit, work with a shift system, and have limited rest time (Anggarini and Indrayanti, 2021). In addition, the number of expert aircraft technicians in Indonesia is still limited, which can increase the workload and the possibility of workers experiencing occupational fatigue becomes greater (Handayani and Demiyati, 2023).

(Asian Productivity Organization, 2022) states that the productivity rate of Indonesian workers is still much lower than countries such as Singapore, Thailand, and Malaysia with the average productivity of individual workers in Indonesia is 24.9 million US Dollars, but still below the ASEAN

average of 28.8 million US Dollars. Productivity is known as a mental attitude that always understands that the quality of life today must be better than yesterday and the quality of today is improved again for the good of the next day (Tarwaka, 2004).

Fatigue is defined by (Mannawaduge et al., 2024) as a physiological state of reduced mental and physical performance ability due to lack of sleep, disrupted circadian phases, and workload (mental and physical) that can interfere with alertness and ability to carry out safety-related operational tasks. In Indonesia alone, most industries use machinery and equipment that will have a positive impact, but can also have a negative impact, especially if not managed properly. One of the negative impacts is as a source of noise for workers (Sari et al., 2021). The same is the case with the machinery and equipment used by aircraft engineers. Long-term exposure to noise will cause changes in the body, such as causing fatigue.

The complexity of aircraft technology makes maintenance a very important function. The working environment of aircraft engineers features non-stop 24-hour working hours, highly diverse and changing working conditions and situations, and demands that can result in poor sleep quality and extremely high workloads. This leads to fatigue such as in aircraft engineers and can increase the likelihood of human error which can directly affect safety (da Silva et al., 2024). The results of a study (da Silva et al., 2024) of aircraft engineers in Portugal and Brazil showed that 52.90% of the aircraft engineers questioned showed fatigue conditions and 12.20% showed very high fatigue. The indicators of fatigue levels studied were sleep quality and workload. According to the International Civil Aviation Organization (ICAO), fatigue is a physiological condition of reduced mental or physical capacity caused by poor sleep quality, prolonged wakefulness, circadian phase, and workload (mental and physical activity) that can interfere with alertness and ability to carry out operational tasks related to safety (International Civil Aviation Organization, 2016). If aircraft engineers experience fatigue, it will certainly have an impact on work, such as difficulty concentrating, making frequent mistakes, and slowing workflow which certainly causes a decrease in productivity.

METHODS

This research was conducted under ethical approval number 1897/UN4.14.1/TP.01.02/2024 and used a mix method with explanatory sequential design. Quantitative data were obtained by measurement, questionnaires, and direct observation which were then analyzed with spss and sem-pls software, then qualitative data were collected by indepth interviews. Secondary data were in the form of journals and reference books, while primary data were collected using interview techniques, questionnaires (SSRT for work fatigue, Nasa-TLX for mental workload, work productivity, Dass-24 for work stress, and PSQI for sleep quality), noise measurements with a sound level meter, measurements (pulse rate, oxygen saturation, and blood pressure with an oximeter and digital tensimeter) for physical workload. The exogenous variables in this study are sleep quality, mental workload, physical workload, noise, and work stress. The endogenous variable is work productivity with work fatigue as an intervening variable.

Respondents in quantitative data are all aircraft engineers of PT GMF AeroAsia at Sultan Hasanuddin International Airport Makassar, totaling 72 people, while qualitative data informants are 4 key informants and 4 main informants. The research was conducted at Sultan Hasanuddin International Airport Makassar, South Sulawesi Province (GMF office area inside the limited security area and apron inside the airport).

RESULTS

Based on individual characteristics, it can be seen that the majority of respondents are aged 30-59 years, namely 54 respondents (75.0%) and the remaining 18 respondents (25.0%) are aged 20-29 years. In addition, the majority had worked >10 years with 41 respondents (56.9%), <6 years with 11 respondents (15.3%), and 6-10 years with 20 respondents (27.8%). The majority of respondents

had attended college with 60 respondents (83.3%) and SMA / SMK as many as 12 respondents (16.7%). Then based on smoking habits, there were 28 respondents who were non-smokers (38.9%), light smokers 22 respondents (30.6%), moderate smokers 20 respondents (27.8%), and heavy smokers 2 respondents (2.8%). Meanwhile, based on Body Mass Index (BMI), the majority of respondents had ideal BMI, namely 34 respondents (47.2%), the rest were underweight 21 respondents (29.2%), overweight 14 respondents (19.4%), and obesity 3 respondents (4.2%).

Based on univariate analysis, the majority of respondents had abnormal blood pressure as many as 38 respondents (52.8%) and normal blood pressure 34 respondents (47.2%). Respondents with abnormal oxygen saturation were 37 respondents (51.4%) and normal oxygen saturation was 35 respondents (48.6%). As for %CVL, the majority of respondents had %CVL that did not cause fatigue, namely 43 respondents (59.7%) and %CVL that caused fatigue as many as 29 respondents (40.3%). In addition, the majority of aircraft engineers experienced low job fatigue as many as 40 respondents (55.6%) and high job fatigue as many as 32 respondents (44.4%). Respondents who had good sleep quality were 38 respondents (52.8%) and poor sleep quality were 34 respondents (47.2%). Based on the mental workload variable, 32 respondents (44.4%) had low mental workload and 40 respondents (55.6%) had high mental workload. Then based on work productivity, respondents with good work productivity were 33 respondents (45.8%) and low were 39 respondents (54.2%). Respondents based on work stress variables, the majority experienced mild work stress as many as 47 respondents (65.3%) and high work stress as many as 25 respondents (34.7%). In addition, the majority of respondents exposed to noise exceeding the NAB were 45 respondents (62.5%) and those exposed to noise not exceeding the NAB were 27 respondents (37.5%).

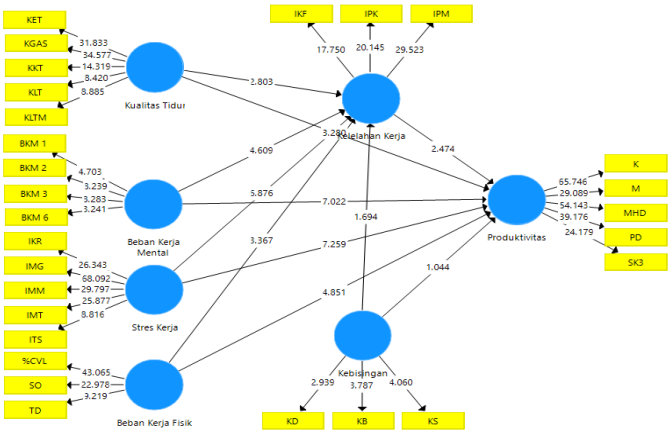
Based on chi square test, it is found that there is a significant relationship between mental workload (0.044), %CVL (0.000), blood pressure (0.015), oxygen saturation (0.031), sleep quality (0.020), work stress (0.003), and noise (0.001) with the respondents' work fatigue, where the p-value of each variable <0.05. In addition, based on the same chi square test, it was found that there was a significant relationship between work fatigue (0.007), mental workload (0.011), %CVL (0.038), blood pressure (0.036), oxygen saturation (0.019), sleep quality (0.030), work stress (0.027), and noise (0.024) with work productivity in GMF AeroAsia aircraft engineers at Sultan Hasanuddin International Airport Makassar in 2024, where the p-value of each variable <0.05.

Table 1. Validity and Reliability of Aircraft Engineer PT. GMF AeroAsia at Makassar Sultan Hasanuddin Airport in 2024

	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Physical Workload	0.838	0.934	0.891	0.732
Mental Workload	0.781	0.799	0.850	0.588
Noise	0.857	2.579	0.871	0.699
Work Fatigue	0.750	0.823	0.851	0.655
Sleep Quality	0.851	0.940	0.874	0.583
Productivity	0.902	0.932	0.927	0.716
Work Stress	0.890	0.938	0.911	0.675

Source: Primary Data, 2024

Based on table 1, it can be seen that the research data has a Cronbach value, rhoa_a, and composite reliability> 0.7, so it is said that all data has good reliability. The AVE value is> 0.5, so it is said that all have good validity.



Hypothesis Test Results Between Variables

Source: Primary Data, 2024

Table 2 Analysis of Direct Effects on Aircraft Engineer PT. GMF AeroAsia at Sultan Hasanuddin Airport Makassar in 2024

	Original Sampel	Mean	Standar Deviasi	T Statistik	P Value
Physical Workload -> Job Fatigue	0.184	0.183	0.055	3.367	0.001
Physical Workload -> Productivity	-0.346	-0.334	0.071	4.851	0.000
Mental Workload -> Job Fatigue	0.331	0.337	0.072	4.609	0.000
Mental Workload -> Productivity	-0.439	-0.414	0.063	7.022	0.000
Noise -> Job Fatigue	-0.129	-0.094	0.076	1.694	0.091
Noise -> Productivity	0.144	0.083	0.138	1.044	0.297
Work Fatigue -> Productivity	0.176	0.174	0.071	2.474	0.014
Sleep Quality -> Work Fatigue	0.219	0.217	0.078	2.803	0.005
Sleep Quality -> Productivity	0.205	0.192	0.063	3.280	0.001
Work Stress -> Work Fatigue	0.403	0.406	0.059	6.876	0.000
Work Stress -> Productivity	-0.488	-0.476	0.067	7.259	0.000

Source: Primary Data, 2024

Based on table 2, multivariate analysis (direct effect) found that physical workload (0.001), mental workload (0.000), sleep quality (0.005), and job stress (0.000) have a direct effect on job fatigue and the effect is positive / direct respectively because the coefficient value is positive. In addition, there is also a direct influence of physical workload (0.000), mental workload (0.000), job fatigue (0.014), sleep quality (0.001), and job stress (0.000) on work productivity. The effect of physical workload, mental workload, and work stress on work productivity is negative/non-directional, while job fatigue and sleep quality have a positive/directional effect on work productivity. Meanwhile, noise has no direct effect on either work fatigue (0.091) or work productivity (0.297) because the p-value is > 0.05.

Table 3. Analysis of Indirect Effects on Aircraft Engineer PT. GMF AeroAsia at Sultan Hasanuddin Airport Makassar in 2024

	Original Sample	Mean	Standard Deviation	T Statistic	P Value
Physical Workload -> Job Fatigue -> Work Productivity	0.032	0.032	0.017	1.913	0.056

Mental Workload -> Occupational Fatigue -> Occupational Productivity	0.058	0.061	0.033	1.776	0.076
Noise -> Occupational Fatigue -> Occupational Productivity	-0.023	-0.017	0.016	1.384	0.167
Sleep Quality -> Work Fatigue -> Work Productivity	0.038	0.036	0.018	2.084	0.038
Work Stress -> Occupational Fatigue -> Occupational Productivity	0.071	0.071	0.031	2.255	0.025

Source: Primary Data, 2024

Based on table 3, it is known that there is no effect of physical workload on work productivity through job fatigue has a p-value of 0.056 <0.05, which means that job fatigue as intervening has no role in mediating physical workload on work productivity (non-mediation). Mental workload on work productivity through job fatigue has a p-value of 0.076> 0.05, which means that job fatigue does not play a role in mediating mental workload on work productivity (non-mediation). As for noise on work productivity through job fatigue, the p-value is 0.167 > 0.05, which means that job fatigue as an intervening variable has no role in mediating noise on work productivity, as well as the direct effect analysis which is not significant, which means that there is no direct effect or indirect effect of these variables.

Based on the sleep quality variable on work productivity through work fatigue has a p-value of 0.038 <0.05, which means that work fatigue as intervening has a role in mediating sleep quality on work productivity (partial mediation) with a coefficient value of 0.038 (positive), so that if sleep quality is poor / decreases, work fatigue decreases, work productivity will also decrease. The work stress variable on work productivity through job fatigue has a p-value of 0.025 <0.05 (significant), which means that job fatigue as intervening has a role in mediating work stress on work productivity (partial mediation) with a coefficient value of 0.071 (positive), so that when work stress increases, job fatigue increases, then work productivity also increases.

DISCUSSION

Effect of Physical Workload on Work Productivity through Work Fatigue at Aircraft Engineer PT. GMF Aeroasia at Sultan Hasanuddin International Airport Makassar.

According to (Tarwaka, 2014), when someone does physical work, muscle activity is needed, so energy is needed in the process, where the energy supply will give a burden to the respiratory and cardiovascular systems. The respiratory system is burdened by physical activity in a job because there is an increase in supplying oxygen demand to the muscles. While the loading on the cardiovascular system occurs because the heart must pump faster to provide oxygen through the blood vessels in the muscles involved.

Based on multivariate analysis in the indirect effect results, it is found that physical workload indirectly has no effect on work productivity through job fatigue (p-value = 0.056> 0.05), but there is a direct effect of physical workload on work productivity (p-value 0.000) and the direction is negative, so that when physical workload increases, work productivity will decrease. This is in line with research conducted by (Galant-Gołębiewska et al., 2022), obtained significant results of physical workload (with pulse rate assessment indicators) on productivity (p-value 0.001 < 0.05). But it is not in line with the regression analysis conducted (Usmawati et al., 2021), where workload has a significant indirect effect on work productivity through job fatigue.

The work of aircraft engineers is known in direct interviews, that there are several work activities that perform static movements or fast movements. Static movements, such as refueling activities (hands raised for a long time), repairing the lower aircraft wall (squatting and bending), installing

aircraft tires (squatting or bending to hold and push the tires during installation) and waiting for the aircraft to land (standing for 10 to 15 minutes). As for the fast movements, such as in the activity of going back and forth up and down the stairs and checking the outside while returning to communication with the crew on the plane where the activity must be done quickly because time is limited.

In the work activities of aircraft engineers there are also activities that use excessive physical energy, such as working the night shift because usually major repairs to the aircraft are carried out at night or when the aircraft stays at the airport and refilling avtur which even though there are already officers, the aircraft engineer still does it for fear of mistakes.

The Effect of Mental Workload on Work Productivity Through Job Fatigue in Aircraft Engineers of PT. GMF Aeroasia at Sultan Hasanuddin International Airport Makassar

In aviation, mental workload is a major factor that significantly impacts work productivity and flightworthiness decisions (Causse et al., 2024). Aircraft engineers receive a very high workload as they are required to work for several hours at high speeds or have to perform many complex tasks without taking breaks to recharge properly, potentially causing fatigue and compromising worker productivity, safety and health (Hobbs, 2008).

Based on multivariate analysis, it is found that there is no indirect effect of mental workload on work productivity through fatigue (p-value = 0.076 > 0.05) or the effect is non-mediation. However, there is a direct effect of mental workload with work productivity (p-value 0.000 < 0.005) and the effect is negative, so that if mental workload increases, work productivity will decrease. This is in line with the results of the interviews conducted, that from several questions related to mental workload it was found that some informants did have a high mental workload. This is because the problems at work are quite complex and there are many tasks, ranging from problems of poor communication with other workers at the airport, planes arriving at almost the same time (not yet taken off one plane, landing another plane), to the problem of work equipment needed that is never available when time is limited when handling aircraft which results in sometimes flight schedules or aircraft take offs delayed.

This research is not in line with research (N. S. Putri et al., 2023), based on sem-pls analysis where it was found that mental workload on work productivity with a t-statistic of 0.078 < 1.96 and a p-value of 0.938 > 0.05 which means that mental workload has no significant effect on work productivity. However, in line with research (Wijayanthi et al., 2024), workload on work productivity has a t-statistic value of 3.775> 1.96 and a p-value of 0.000 < 0.05, it can be concluded that workload has a significant positive effect on work productivity.

The Effect of Noise on Work Productivity Through Work Fatigue at Aircraft Engineer PT. GMF Aeroasia at Sultan Hasanuddin International Airport Makassar

One of the factors that can affect worker productivity is noise. The level of noise quality is caused by machines or work tools that are operating at the airport, in this case the noise coming from the aircraft.

Based on multivariate analysis with sem-pls, it was found that mental workload has no direct effect on work productivity (p-value = 0.297 > 0.05) and there is also no indirect effect of work environment noise on work productivity through fatigue (p-value = 0.167 > 0.05). Since there is no direct effect or indirect effect, no qualitative research or analysis was conducted. Based on observations made, it is known that aircraft engineers are exposed to noise coming from aircraft engines, such as turbine engines and APU. These aircraft engineers only use earplugs when working on the aircraft because they think it is easier to wear and not disturbing. If earmuffs are indeed inaudible but the voices of

people communicating with them are also inaudible, so they choose earplugs because other people's voices are still audible.

This research is in line with research (Kurnianto and Munang, 2023), that there is no significant effect of noise on work productivity (p-value 0.886 > 0.05). In contrast to research conducted by (Rahayu and Cahyadi, 2020) the effect of noise intensity on work fatigue obtained a p-value of 0.001 ≤ 0.01, so there is an effect of noise intensity on work fatigue, thus affecting work productivity. Exposure to high-intensity noise in the workplace environment may be unavoidable for workers who are in the surrounding environment, one of which is the air side of the airport. Ear protection devices, both ear plugs and ear muffs, have the benefit of reducing the noise level exposed to noise sources that can affect auditory and non-auditory (B. A. Putri et al., 2021).

The Effect of Sleep Quality on Work Productivity Through Work Fatigue in Aircraft Engineers of PT. GMF Aeroasia at Sultan Hasanuddin International Airport Makassar

Teams of aircraft engineers work in 24-hour shifts to ensure the accuracy of flight schedules. Irregular working hours, unpredictable situations and night shifts that disrupt sleep and wake cycles can interfere with the ability to get enough sleep, making it difficult to adopt a healthy and balanced lifestyle. Disruption of the body's circadian rhythm can lead to a decrease in the quality and quantity of sleep, causing high fatigue, disrupted daytime activities due to drowsiness, and difficulty focusing, resulting in poor work productivity (Shiftan and Wilson, 1994).

Based on the results of the indirect effect of multivariate analysis, it is found that sleep quality indirectly has an influence on work productivity through work fatigue (p-value = 0.038) and the effect is positive / direct (coefficient = 0.038) so that if sleep quality decreases, work fatigue decreases, work productivity will also decrease. When viewed on the results of direct effect and indirect effect that are significant, it is known that the results of multivariate analysis are partial mediation (sleep quality has a direct effect on work productivity and also has an indirect effect through job fatigue). In this study, sleep quality decreased, work fatigue also decreased, and so did work productivity. Based on the results of the interviews, this is because some informants said that when they experience sleep disturbances or when sleep quality is poor, they can take advantage of short breaks at the office to steal sleep time until the scheduled plane to be handled will land. Even so, poor sleep quality can make productivity also poor because when experiencing sleep disturbances, informants have been late for work or need to be replaced by coworkers (where this is one of the assessments or indicators that can be seen from a person's work productivity, namely work discipline and responsibility).

This study is in line with research (Mobarak et al., 2023) conducted on workers in the UAE, which found that insomnia or poor sleep quality has a direct negative effect on work productivity. But it is not in line with research (Pratiwi et al., 2023), that sleep quality has no significant effect on job fatigue (p-value 0.446 > 0.05). This relationship indicates that the variables of sleep quality and work fatigue do not have a statistically strong relationship.

The Effect of Job Stress on Work Productivity Through Job Fatigue at Aircraft Engineer PT. GMF Aeroasia at Sultan Hasanuddin International Airport Makassar

According to (The National Institute for Occupational Safety and Health, 1999), stress is a physical and emotional response resulting from a mismatch between the demands of the job and the worker's abilities, resources, and desires that can have adverse effects . In aviation, stress is a major factor that has a significant impact on work productivity and flightworthiness decisions. Highly complex tasks can be stressful if a person feels unable to cope with them (Causse et al., 2024). Technicians who experience job stress will be overwhelmed by feelings of anxiety, tension, and irritability.

Based on the results of indirect effect multivariate analysis, it is found that work stress indirectly has an influence on work productivity through job fatigue (p-value = 0.025) and the effect is positive / direct (coefficient = 0.071) so that if work stress increases, job fatigue increases, work productivity will also increase. When viewed at the significant direct effect and indirect effect results, it is known that the multivariate analysis results are partial mediation (work stress has a direct effect on work productivity and also has an indirect effect through job fatigue). Based on the results of the interviews, the reason work productivity continues to increase even though work stress and job burnout increase is because there are several informants who say they will still try to solve work problems with good communication and maintain emotions, so that their work is completed on time and on target. In addition, in work productivity there are also several indicators that can be assessed, such as skill development (the company has run training) and ability or work enthusiasm (workers understand that work is an obligation, responsibility, and there are targets to be achieved).

Based on some informants' answers, they also found it difficult to rest because they were afraid of being sleepy when the plane landed, gout flared up, body pain, or because there were many people and small spaces in the office. According to some informants, such difficulty in resting sometimes causes fatigue if it occurs frequently (with symptoms such as lack of focus, forgetfulness, and other emotional changes). That is what makes job stress increase, and thus job burnout also increases.

This research is in line with research (Dora et al., 2022) that work stress with work productivity is found to be significant (0.000 <0.05) which means that the work stress variable partially has a significant effect on work productivity. This is because too much work stress can cause tension due to skills that are demanded too high, work speed is too high, and work volume is too much. However, this study is not in line with research (Rahmawati et al., 2021), which found that work stress partially has a negative and insignificant effect on worker productivity.

CONCLUSION

Based on the results of research on the Analysis of Work Productivity Through Work Fatigue on Aircraft Engineers at Sultan Hasanuddin Airport Makassar in 2024, it can be concluded that first, mental workload has a relationship and direct influence (non-mediation) negative / direct to work productivity. Second, sleep quality has a relationship with work productivity and partial mediation is obtained because sleep quality directly affects work productivity and indirectly also affects through job fatigue (the effect is positive / direct). Third, physical workload has a negative/non-directional relationship and direct influence (non-mediation) on work productivity. Fourth, work stress has a relationship with work productivity and partial mediation is obtained because work stress directly affects work productivity and indirectly also affects work productivity through job fatigue (the effect is positive/directional). Fifth, noise has a relationship with work productivity and job fatigue based on bivariate analysis, but noise has no direct effect on work productivity or indirectly through job fatigue. The limitation in this study is that each variable is only subjectively assessed due to limited information from the agencies studied and the measuring instruments used.

AUTHORS' CONTRIBUTIONS

DEP in writing has conducted research by going directly to the field to conduct observations and interviews with the object of research. LMS and FN contributed in providing input and ideas related to research ranging from good methods to be used to research targets. SSR and FR contributed to testing the research results and providing input or criticism to improve the writing.

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