JURNAL ILMIAH TEKNIK INDUSTRI
ISSN: 1412-6869 (Print), ISSN: 2460-4038 (Online)
Journal homepage: http://journals.ums.ac.id/index.php/jiti/index
doi: 10.23917/jiti.v23i1.3209

Impact of Fatigue, Sleep Quality, and Drowsiness on Medical Laboratory Technologists' Alertness During Night Shift

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Abstract. *Medical Laboratory Technologists (MLTs) often work in shifts, with night shifts being much longer than morning or day shifts. As a result, many MLTs are exposed to high levels of fatigue, sleep problems, and drowsiness, while MLTs are always required to be alert for emergency analysis. This research aims to determine the impact of fatigue, sleep quality, and drowsiness on decreased alertness of MTLs working night shifts. Additionally, it describes the fatigue, sleep quality, drowsiness, and decreased alertness of MLTs. The method of analysis used was multiple linear regression. The research found that most MLTs working night shifts suffer from high fatigue levels, poor sleep quality, drowsiness, and decreased alertness. The findings suggest that fatigue and drowsiness have an impact on decreased alertness, while sleep quality has no impact on decreased alertness. These findings have implications for work scheduling and managing fatigue and drowsiness among MLTs.*

Keywords: *alertness; drowsiness; fatigue; night shift; sleep quality.*

I. Introduction

Shift work that requires a rotating schedule can lead to decreased alertness and performance as the result of sleep deprivation and disrupted circadian rhythms, especially on night shifts (Bihari et al., 2020; Ganesan et al., 2022). The consequences of decreased alertness can be fatal, as errors are more likely to occur (Bihari et al., 2020). Additionally, fatigue can further decrease alertness, especially in jobs that require accuracy, precision, and pose a high risk (Min, Hong, Son, & Lee, 2021). Night shift work disrupts sleep patterns and can negatively impact health due to fatigue (Sun, Ji, Zhou, & Liu, 2019).

Night shift work significantly impacts sleep patterns due to the disruption of circadian rhythms and increased stress on sleep homeostasis. This leads to sleep problems, which have a detrimental impact on other facets of well-being as well as cognitive function, thereby increasing the risk of accidents and errors at work (Alfonsi et al., 2021). Previous research indicated that night shifts can negatively impact sleep duration and quality, while also showing a significant correlation between sleep quality and drowsiness on alertness (Di Muzio et al., 2019; Rosa et al., 2021; Stavrou et al., 2021). However, no previous research has specifically investigated the impact of fatigue, sleep quality, and drowsiness on decreased alertness among MLTs working night shifts, especially in Indonesia.

Medical Laboratory Technologists (MLTs) are crucial in ensuring patient safety. MLTs take responsibility for doing numerous laboratory tests and analyses on the orders of physicians, surgeons, or healthcare workers to aid in diagnosing, treating, and preventing patient disease (Bureau of Labor Statistics, 2023). MLTs are responsible for accurate and reliable test results, as these results directly impact patient diagnosis, care, and treatment, impacting patient safety (Achmad, 2022; Arifin & Sjaaf, 2020; Jafri et al., 2015). Therefore, MLTS need to maintain high alertness and accuracy in their work.

In providing health services to the community, a private hospital in West Jawa, Indonesia, operates on a 24-hour system with three shifts: morning, day, and night. The morning shift is from 7:00 AM to 2:00 PM (7 hours), the day shift is from 2:00 PM to 9:00 PM (7 hours), and the night shift is from 9:00 PM to 7:00 AM (10 hours).

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Submited: 23-10-2023 Revised: 06-06-2024
Accepted: 15-06-2024

Several MLTs who work at that private hospital expressed complaints regarding their experience while working on the night shift. Specifically, MLTs felt burdened by the hospital's work schedule, which required longer shifts during the night. During a long night shift, MLTs experience decreased attention, quickly get tired, drowsiness, and may even feel depressed while performing emergency analysis. As a result of long night shifts, MLTs also reported disrupted sleep and various health issues, including joint and back pain, and headaches. These preliminary interviews provide insight into the potential challenges faced by MLTs working during nighttime hours.

According to the Head of the Laboratory, there were several cases where MLTs made errors while performing their work. In one month, there were at least five errors in the results of laboratory tests. MLTs usually make errors in testing, labeling, and checking equipment. Decreased alertness can lead to errors in carrying out the correct test steps, resulting in inaccurate results. This can lead to incorrect diagnosis or inappropriate patient treatment. Mislabeling of samples or data recording errors can also lead to confusion or errors in interpreting results. This can impact the medical decisions made based on the results. Medical laboratory equipment must also be properly maintained and calibrated. If the MLTs are not alert enough in routine checks or equipment maintenance, there could be errors in tests and measurements.

Based on previous research and the concerns, it has been observed that Medical Laboratory Technologists (MLTs) who work night shifts experience fatigue, sleep problems, and drowsiness, which may lead to a decrease in alertness levels. The objective of this research is to determine the impact of fatigue, sleep quality, and drowsiness on decreased alertness levels of MTLs who work on night shifts. In addition, it describes fatigue, sleep quality, drowsiness, and decreased alertness of MLTs who work on night shifts. This research can identify factors contributing to decreased alertness in MLTs who work night shifts so that measures can be formulated to reduce the risk of decreased alertness in MLTs. A causality model for this research is in Figure 1.

H1 : Fatigue, sleep quality, and drowsiness impact decreased alertness on night shift.

H2 : Fatigue impacts decreased alertness on night shifts.

H3 : Sleep quality impacts decreased alertness on night shift.

H4 : Drowsiness level impacts decreased alertness on night shifts.

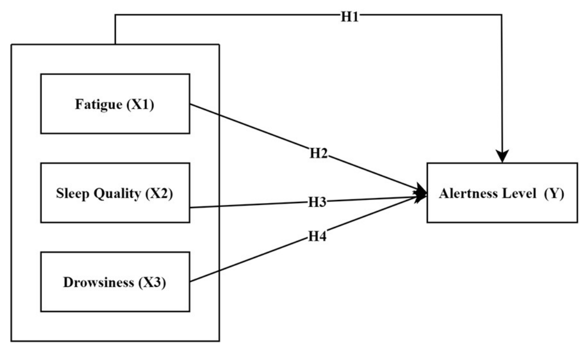

Figure 1. Conceptual model

II. Research Method

Population and Sample

This research population was Medical Laboratory Technologists (MLTs) who have night shifts at a private hospital in West Java, Indonesia, with a total of 31 participants. In this research, saturated sampling (census) was used for data collection, where all members of the population were sampled because the population was relatively small (Sugiyono, 2019). Therefore, the sample in this research was 31 Medical Laboratory Technologists (MLTs).

Data Collection

Data collection were conducted through the Vigilance Buddy app and questionnaires to collect primary data, which was divided into two parts, before and after working a night shift. Before working, MLTs assessed alertness for 3 minutes using the Vigilance Buddy app. No assessments were administered during work hours, but after working, MLTs assessed alertness for 3 minutes using the Vigilance Buddy app and then completed a questionnaire for 12 minutes. The questionnaires included the FAS (Fatigue Assessment Scale), PSQI (Pittsburgh Sleep Quality Indeks), and KSS (Karolinska Sleepiness Scale). The illustration of data collection procedures is in Figure 2.

Before working	3-minute Vigilance Buddy assessment
While working	No assessment
After working	3-minute Vigilance Buddy assessment and complete the questionnaire (FAS, PSQI and KSS)

Figure 2. Data collection procedures

Data Measurement Tools

1. Alertness. Alertness is the individual's ability to maintain attention, accuracy, and precision within a certain duration of time. The Psychomotor Vigilance Task (PVT) is one method for assessing alertness (Grant, Honn, Layton, Riedy, & Van Dongen, 2017). The mobile version of PVT involves pressing a screen as quickly as possible in reaction to a randomly appearing number, lasting about 5-10 minutes. The time it takes to react is measured in milliseconds. This research used the "Vigilance Buddy" mobile application for 3 minutes, where the 3-minute PVT can replace the 10-minute PVT (Benderoth, Hörmann, Schießl, & Elmenhorst, 2021; Grant et al., 2017).
2. Fatigue. Fatigue is a condition where the individual can no longer perform their tasks. The FAS (Fatigue Assessment Scale) is one way to assess fatigue. FAS comprises ten queries to express overall feelings of fatigue. This research used the Indonesian FAS questionnaire translated by Zuraida and Chie (2014). The total score is obtained by adding all scores per item and classified into two categories: score 1-25 is considered "low" job fatigue, while score 26-50 indicates "high" job fatigue. The Indonesian edition of the FAS questionnaire generally shows good validity as it has r values ranging from 0,5 to 0,7 and good reliability with an alpha Cronbach coefficient 0,714. These results indicate that the Indonesian FAS was reliable for measuring job fatigue (Ramdan, 2019).
3. Sleep Quality. Sleep quality refers to the satisfaction individuals feel with their sleep experiences. The PSQI (Pittsburgh Sleep Quality Indeks) is one way to assess sleep quality. The PSQI assesses an index of sleep quality based on seven parameters: daytime dysfunction, subjective sleep quality, sleep disturbances, sleep efficiency, use of sleep-affecting drugs, sleep latency, and sleep duration. The scores derived from all seven parameters are then totaled, resulting in a total score that ranges between 0 and 21. When the total score of the PSQI as greater than 5, it is indicative of the individual's poor sleep quality (Lee et al., 2020). This research used the PSQI questionnaire from Rosyidah's research (2022). The PSQI questionnaire has already been validated and reliable, with calculated r value between 0,406 – 0,867 and a Cronbach alpha value of 0,747 (Rosyidah, 2022).
4. Drowsiness. Drowsiness is a condition that arises from the urge to sleep and be awake for a long time. Assessing individual drowsiness is possible through the use of a subjective method called the Karolinska Sleepiness Scale (KSS). This method involves answering question in 9 different scores. Many studies rely on KSS to measure drowsiness because of its simplicity in collecting and processing data. This research used the Indonesian version of KSS translated by Mahachandra, Munzayanah, and Yassierli (2017). KSS has two groups: levels 1-5 are "aware" and 5-9 are "sleepy".

Data Analysis

This research employed Microsoft Excel to determine mean, range, and percentage frequency. Multiple linear regression tests were conducted using SPSS software version 25.0 to to examine the impact of fatigue, sleep quality, and sleepiness on decreased alertness. The regression model was utilized to conduct the F test, t test, and R2 (coefficient of determination). The F test was utilized to establish whether all independent variables impact dependent variable. The t test was utilized to establish how significant impact an independent variable has on the dependent variable individually. Furthermor, the R2 (coefficient of determination) was utilized to establish the percent of independent variables that can jointly explain the dependent variable.

III. RESULT AND DISCUSSION

Results

1. Alertness Level. Based on the comparison of the alertness levels before and after night shift work in Figure 3, it was observed that MLTs experienced a decrease in alertness levels during their night shift. This indicates that as the night shift progresses, their alertness levels decrease.
2. Fatigue and Drowsiness. Based on **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, and Figure 4, it was found that MLTs commonly feel very tired and sleepy (with an average KSS score of 5,32) when working during the night shift. This was due to the tendency to disregard the impact of inadequate sleep during the night shift and the difficulty in adjusting to the reversed work schedule, ultimately leading to increased fatigue (especially physical fatigue) and drowsiness during the shift period.
3. Sleep Quality. Based on Table 4, it was found that MLTs generally experienced poor sleep quality, with 28 people experiencing poor sleep quality. This is because MLTs have difficulty starting to sleep. Based on interviews with MLTs, it was discovered that most MLTs have a habit of playing on mobile phones before going to bed. This caused MLTs an average of 35,23 minutes to fall asleep (Table 5).
4. Hypothesis Test. The F test is frequently used in regression analysis to assess whether all independent variables impact dependent variables. The F test result is shown in Table 1.

Table 1. Descriptive statistics of fatigue (n=31)

Item	Mean	Range
Item score (0-3 possibility)		
1. Disturbed with fatigue	2,58	2-4
2. Gets tired very easily	2,61	2-5
3. Not much activity during the day	2,52	2-5
4. Have sufficient energy for daily life	3,03	2-5
5. Feeling physically exhausted	3,16	2-5
6. Difficulty to start things	2,03	1-3
7. Difficulty to think clearly	1,77	1-3
8. No will to do anything	2,13	1-4
9. Feeling mentally exhausted	2.77	1-5
10. Can concentrate fairly well	2,94	2-5

Table 2. Frequency distribution of fatigue of MLTs on night shift

Fatigue Categories	Frequency (N)	Percentage (%)
Low	14	45.16
High	17	54.84
Total	31	100

Table 3. Descriptive statistics of drowsiness level (n=31)

Variable	Mean	Range
Drowsiness Level (1-9 possible)	5,32	1-9

Table 4. Frequency distribution of sleep quality of MLTs on night shift

Sleep Quality Categories	Frequency (N)	Percentage (%)
Poor	28	90.32
Good	3	9.68
Total	31	100

Table 5. Descriptive statistics of sleep quality (n=31)

Parameters	Mean	Range
Parameters score (0-3 possibility)		
1. Subjective sleep quality	1,29	0-3
2. Sleep latency	1,71	0-3
3. Sleep duration	1,52	0-3
4. Sleep efficiency	0,45	0-2
5. Sleep disturbances	1,65	0-3
6. Use of sleep-affecting drugs	0,45	0-3
7. Daytime dysfunction	1,35	0-2
Minutes to falling asleep	35,23	1-120
Real-time sleep per night (hours)	6.13	5-8

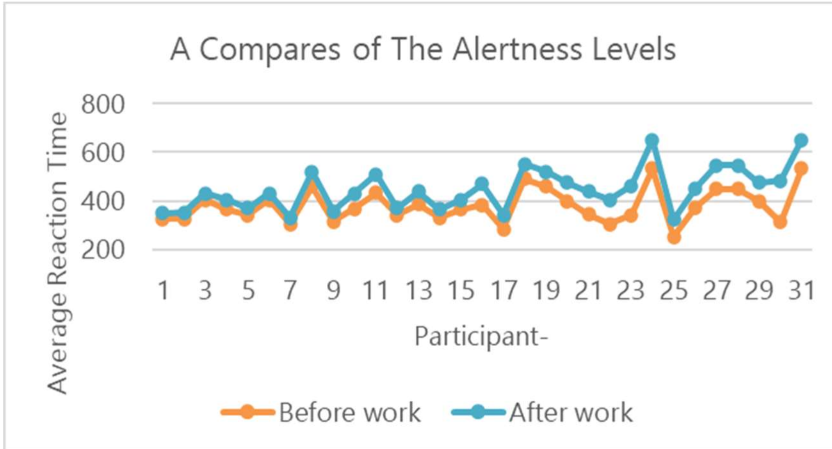

Figure 3. Comparison of the alertness levels of MLTs before and after night shift work

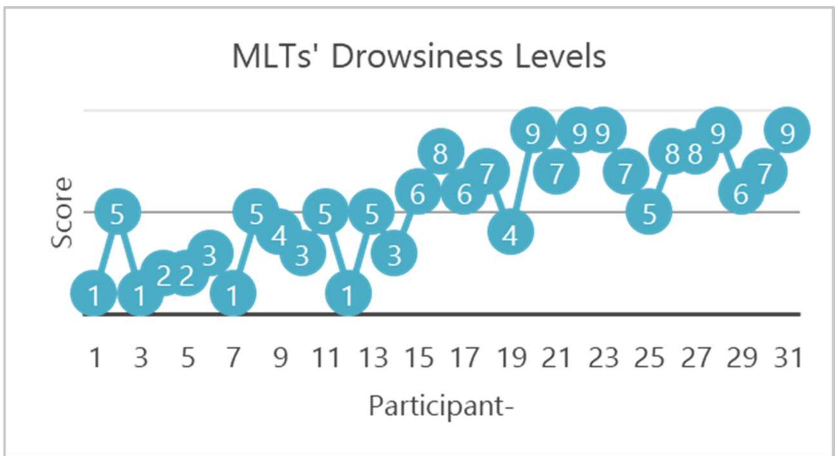

Figure 4. MLTs' drowsiness levels during the night shifts work

According to the data presented in Table 1, it can be deduced that the F value is higher than the F-table, and the significance value is less than 0,05. As a result, hypothesis 1 is supported. These findings suggest that fatigue, sleep quality, and drowsiness simultaneously impact the decrease in the level of alertness on the night shift.

The t test is utilized to establish how significant impact an independent variable has on the dependent variable individually. The t test results are shown in Table 2.

According to the data presented in Table 2, it can be deduced that the significance values of hypotheses 2 and 4 are less than 0,05. As a result, hypotheses 2 and 4 are supported. In contrast, the significance values of hypothesis 3 is greater than 0,05. As a result, hypothesis 3 is not significant or not supported. These findings suggest that fatigue and drowsiness partially impact the decrease in alertness on the night shift. In contrast, sleep quality does not partially impact the decrease in the level of alertness on the night shift. Therefore, it can be concluded that the more tired and sleepy the MTL is, the lower the alertness.

5. Coefficient of Determination (R2). The regression results in this research also showed the level of explanation for independent variables on a dependent variable, which is represented by the value of Adjusted R^2. A lower Adjusted R^2 value means the dependent variables do not easily explain the independent variables. On the other hand, as the Adjusted R^2 value approaches one, it indicates that the independent variables'

Table 1. F-test result

Hypothesis	F	F-table	Sig
1	24,081	2,96	0,000

Table 2. t-test results

Hypothesis	Sig	P-value	Result
2	0,012	0,05	Significant
3	0,056	0,05	Not Significant
4	0,009	0,05	Significant

Table 3. Coefficient of determination (R^2)

R^2	Adjusted R^2
0,728	0,698

variation can almost entirely be predicted using the dependent variables, meaning that they provide most of the necessary information. Table 3 shows the coefficient of determination results.

According to the data presented in Table 3, it can be deduced that the Adjusted R^2 value is 0,698. These findings suggest that fatigue and drowsiness contribute to 69,8% of the level of alertness in the night shift. In comparison, the remaining 30,2% is impacted by other variables not included in the research.

Discussion

Night shift work often leads to disturbances in alertness and performance through sleep deprivation and circadian cycle misalignment (Bihari et al., 2020; Ganesan et al., 2022). According to Figure 3, there was found that there was a decrease in the level of alertness of MLTs who worked night shifts. These results were aligned with Bihari et al. (2020) and Wilson et al. (2019) which showed that night shifts have a significant relationship with alertness.

The decreased alertness can cause errors in doing work (Bihari et al., 2020). This is proved during data collection. There was one analysis error during the night shift, so MLTs had to identify the cause of the error from the blood sample testing and repeat the testing process. Such conditions can disrupt laboratory workflow, result in delays in testing, and, in turn, slow down patient diagnosis and treatment.

The results in Table 2 revealed that most MLTs experienced fatigue in the high category, especially physical fatigue with the highest mean of 3.16 (Table 1), which means that most MLTs regularly experience physical fatigue during working night shifts. These results were aligned with the research of Ganesan et al. (2019), which showed that the tendency to ignore the pressure of insufficient sleep duration in night shift work resulted in fatigue levels that continued to increase during the work period.

The fatigue condition of MLTs working in the night shift is also caused by the duration of work in the night shift, which is longer than other shifts (10 hours). This duration exceeds the guidelines recommended by the Indonesian Ministry of Manpower (2018), stipulating that working hours should not exceed 8 hours per day. As mentioned by Ganesan et al. (2019), night shifts and long working hours will result in increased levels of fatigue that can impact workers' cognitive efficiency. Fatigue conditions can also be exacerbated when MLTs are required to work two shifts at once. This situation has occurred several times in the hospital concerned, where some MLTs have worked double shifts because there are MLTs who cannot attend due to leave or illness.

According to the results of this research, it can be deduced that fatigue experienced by MLTs can be caused by various factors, including inadequate sleep duration, extended work duration, and working in two shifts at once. These factors underline the importance of setting and managing an efficient work schedule to maintain MLTs' overall health and well-being. Therefore, it is crucial to prioritize implementing efficient work schedule and better fatigue management practices to maintain the health and performance of MLTs.

This research also showed that fatigue impacts the decrease in the level of alertness of MLTs (hypotheses 2). These results were also aligned with the research results by Min et al. (2021), which showed that fatigue significantly impacts the decrease in alertness. In general, the results of this research indicate that fatigue management and efficient organization and management of work schedules are essential for individuals who work in jobs that require continuous alertness and concentration.

To reduce the high fatigue levels in workers, utilization of recovery room has proven to be an efficient method. Previous research shows that allowing workers access to these rooms significantly improves the quality of their rest, resulting in a faster recovery process (Qosim & Setyaningsih, 2021). According to Law No. 13 (2003) Article 100 Paragraph (3), it is mandatory for companies to provide welfare facilities for their workers. This includes resting room or recovery room facilities. However, the hospital does not have facilities such as recovery room for MLTs to rest, which can interfere with the recovery process needed by MLTs. Barthe, Tirilly, Gentil, and Toupin (2016) revealed that the ideal resting room (recovery room) would be soundproof and have beds for workers to rest and take naps.

Hospital management can prevent MLTs' fatigue by offering adequate rest facilities (recovery room) and improving the work schedule system by avoiding excessively long work durations and ensuring adequate breaks between work schedules. Work hours can be split into recommended 8-hour blocks to improve scheduling. These measures can minimize the risk of fatigue-related mistakes and decreased alertness, leading to better performance and productivity for hospitals and MLTs.

Another result of this research was that most MLTs had poor sleep quality, with sleep latency being the most significant factor affecting their sleep (Table 5). Sleep latency refers to the time required for an individual to begin falling asleep after getting into bed. In the context of sleep, it measures how quickly a person can enter into the sleep phase after trying to sleep (Shrivastava, Jung, Saadat, Sirohi, & Crewson, 2014). The research indicated that MLTs experienced difficulty initiating sleep, taking 35,23 minutes. Interviews with MLTs revealed that many habitually used their mobile phones before going to bed, which exacerbated the issue (Exelmans, Van den Bulck, & Medicine, 2016; Krishnan, Sanjeev, & Latti, 2020).

Despite the poor quality of sleep experienced by MLTs, the research found that sleep quality does not impact the level of alertness of MLTs on the night shift (hypotheses 3 not significant). This was because the primary factor impacting the poor sleep quality was sleep latency, which did not affect their working condition (Park, Lee, & Park, 2018). The research results were aligned with previous research by Pratama and Ramdhan (2023), which also showed no correlation between sleep quality and alertness. However, these findings contradict the research of Stavrou et al. (2021) which suggested that poor sleep quality resulting from sleep time restrictions can impact perceptual abilities and alertness. In contrast, this research demonstrated that sleep time restrictions not the primary factor impacting the poor sleep quality. Although MLTs experienced sleep deprivation during their night shift, they were able to compensate for the lack of sleep by resting more on their days off.

According on the results of measuring the level of drowsiness in Table 3 and Figure 4, it can be identified that most MLTs experienced drowsiness while working night shifts. This research also found that the level of drowsiness impacts the decrease in alertness levels (hypotheses 4). These results were aligned with research by Di Muzio et al. (2019), which showed a significant correlation between drowsiness and alertness. As a result, when the level of drowsiness increases, the level of alertness will decrease, making it difficult for MLTs to maintain focus and concentration during the night shift. Taking 30-min scheduled nap during work-shift hours can decrease drowsiness, increase alertness, improve overall sleep duration, and enhance response accuracy (Han et al., 2021; Li et al., 2019; Ruggiero & Redeker, 2014; Zion & Shochat, 2019). Scheduled nap can be taken on a rotation basis, allowing MLT to sleep while making sure coworkers remain alert and take over. This research highlights the importance of adequate rest during work-shift hours to ensure optimal performance and alertness of MLTs.

After analyzing the data, it can be inferred that performing night shifts has a negative impact on the alertness level of Medical Laboratory

Technicians (MLTs). The decrease in alertness level is impacted by the feelings of fatigue and drowsiness that arise from working during the night. This suggests that the experience of fatigue and drowsiness can severely impact the ability of MLTs to maintain a high level of alertness while performing their job duties. The research indicates that fatigue and drowsiness contribute to 69,8% of the decrease in alertness, while the remaining 30,2% can be contributed to other variables not included in the research. Future research can explore additional factors, such as age, job demands, and physical work environment, that may contribute to a decrease in alertness levels.

IV. CONCLUSION

According to the research, most Medical Laboratory Technologists (MLTs) working night shifts suffer from high fatigue levels, poor sleep quality, drowsiness, and decreased alertness. The findings suggest that fatigue, sleep quality, and drowsiness simultaneously impact decreased alertness. Fatigue and drowsiness have a partial impact on decreased alertness. In contrast, sleep quality has no partial impact on decreased alertness. These findings have implications for work scheduling and managing of fatigue and drowsiness among MLTs who work on night shifts.

To improve the work schedule system, it can be improved by avoiding excessively long work durations and ensuring adequate breaks between work schedules. Work hours can be split into recommended 8-hour blocks. To manage of fatigue and drowsiness, it can be improved by offering adequate rest facilities (recovery room) and scheduling 30-min nap during work-shift hours. Future research can explore additional factors, such as age, job demands, and physical work environment, that may contribute to a decrease in alertness levels.

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