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Research Article

Understanding the Correlation Between Boredom Proneness Induced Sleepiness and Microsleep Events Among Drivers

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Abstract

Driving is a crucial daily activity that requires high concentration to ensure safety on road. One of the factors contributing to traffic accidents is the phenomenon of microsleep, a brief involuntary sleep episode that can disrupt a driver's alertness. In Indonesia, particularly in Province of Aceh, traffic accident rates remain relatively high. The Banda Aceh-Medan Road segment is one of the areas with the highest traffic accident rate in Aceh Province. This highlights the importance of the research. This study aims to analyze the factors affecting the occurrence of microsleep among drivers in Aceh Province, specifically focusing on the ease of falling asleep that was measured using the Epworth Sleepiness Scale (ESS). Whilst, the boredom was measured using the Boredom Proneness Scale (BPS). Data were collected through questionnaires distributed to 310 drivers who had travelled the Banda Aceh - Medan route, both on expressways and national road. The Structural Equation Modelling (SEM) method was used to examine the relationships between the exogenous latent variables (boredom level and sleepiness) and the endogenous latent variable (frequency of microsleep). The model indicates there were relationship between three main latent variables. Boredom Proneness (BP) has a significant positive effect on the Epworth Sleepiness Scale (ESS) with an estimate coefficient of 0.329 ($p < 0.001$). BP also positively affected Microsleep (MS) with an estimate of 0.242, and the ESS positively influenced the MS with a coefficient of 0.191, respectively. The overall model demonstrated acceptable statistical quality with RMSEA = 0.079, GFI = 0.850, AGFI = 0.813, and CFI = 0.842, indicating a marginal to good fit. However, this study is limited by its cross-sectional and self-reported design, suggesting future research should apply experimental or physiological approaches to better capture driver fatigue dynamics.

Keywords: Microsleep, Epworth Sleepiness Scale, Boredom Proneness

Introduction

Transport safety is a serious issue that must be addressed to ensure the safety and security of its users [1]. Traffic accidents are one of the top ten leading causes of death worldwide. Since the awareness of transportation safety increases, various studies have been conducted to analyze the factors influencing driver performance and safety, aiming to develop effective preventive measures [2]. According to Kumala et al. [3], traffic accidents are one of the leading causes of death in Indonesia. On February 22, 2024, the number of traffic accidents in Indonesia accounted 163 cases in a single day [4]. In Aceh Province specifically, traffic accidents remain a significant issue. The Aceh Regional Police Traffic Directorate recorded 304 traffic accident cases in March 2024, reflecting an 11% increase from the previous month [5].

There are three overland routes connecting Aceh and North Sumatra: The Eastern Corridor, The west coast southern, and the central road corridors [6]. Among these, the Eastern Corridor serves as the primary and fastest connection due to its superior road conditions, adequate infrastructure access, and integration with several toll road segments.

However, its long, straight, and monotonous road characteristics frequently induce highway hypnosis, particularly among public transport drivers who traverse the route regularly. With travel times reaching 13–15 hours, many drivers continue without adequate rest, while the corridor is heavily occupied by large vehicles, thereby increasing the likelihood of hazardous maneuvers especially as most vehicles travel at high speeds [7]. Insufficient lighting in several segments further heightens the risk of nighttime accidents. Consequently, this route is recorded as one of the corridors with the highest incidence of traffic accidents in Aceh Province [8].

In 2021, more than 100 traffic accidents in Aceh were attributed to drowsy driving [9]. While physical fatigue and workload are frequently cited as the primary causes [10,11]. Psychological factors such as boredom proneness have received relatively few academic attentions, particularly in Aceh. In fact, monotonous, repetitive, and visually unstimulating roads can diminish driver alertness and trigger drowsiness [12,13]. Prajitna [14] further observed that boredom significantly influences driving behavior in urban areas.

Accordingly, this study aims to analyze the effect of boredom on drowsiness and microsleep tendencies, with the following hypotheses i.e., (1) boredom positively affects drowsiness, (2) boredom positively affects microsleep, and (3) drowsiness positively affects microsleep.

Literature Review

Transportation safety has long been recognized as a multidimensional issue encompassing physical, psychological, and behavioral aspects of drivers. In recent years, numerous studies have highlighted that impaired driving performance is not solely caused by physical fatigue, but also by psychological conditions such as boredom and sleepiness, which can trigger microsleep episodes. These conditions represent critical precursors to traffic accidents, particularly among drivers engaged in long-distance travel along monotonous routes [10–13].

Boredom is a psychological state that arises when individuals are exposed to repetitive, predictable, and mentally unstimulating environments. In the context of driving, boredom frequently occurs on long, straight, and visually monotonous roads such as the Banda Aceh–Medan national corridor where drivers experience reduced cognitive stimulation and decreased alertness. According to Peiris et al. [15], boredom during driving can significantly lower vigilance and induce drowsiness. Similarly, Kass et al. [16] and Wallace et al. [17] noted that individuals with high boredom proneness tend to experience cognitive decline and concentration lapses while driving. This suggests that diminished mental stimulation and reduced neural activity can elicit sleepiness even in the absence of physical exhaustion.

Sleepiness represents a transitional state between wakefulness and sleep, characterized by reduced alertness, weakened concentration, and slower reaction times. A survey conducted by the National Sleep Foundation [11] reported that 32% of respondents admitted to feeling drowsy while driving at least once a month, and 2% had experienced an accident resulting from sleepiness. When this condition remains unaddressed, drivers may experience microsleep brief, involuntary episodes of sleep lasting several seconds [18]. During microsleep, drivers lose situational awareness and exhibit delayed responses to traffic stimuli. Johansson and Rumar [19] observed that reaction time during unexpected events increases by up to 35%, underscoring the severe impact of microsleep on driving capability and safety.

The interaction between boredom, sleepiness, and microsleep reflects an interrelated psychological mechanism that progressively deteriorates driving performance. Monotonous road environments characterized by uniform scenery and minimal visual variation reduce cognitive stimulation and attentional arousal [20]. Under such conditions, the brain exhibits decreased neural activity, triggering drowsiness; when sleepiness is left unmanaged, microsleep episodes are likely to occur. These brief lapses result in loss of focus and control, substantially increasing the risk of traffic accidents.

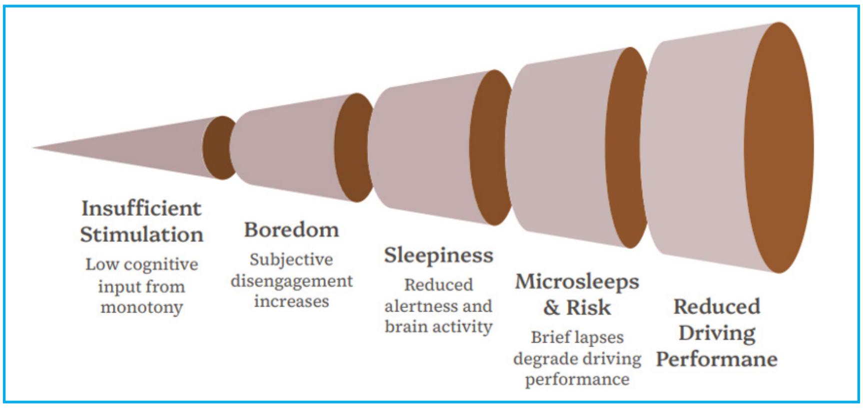

Figure 1. The Monotony-to-Microsleep Causal Chain framework

Based on these findings, the conceptual framework of this study is illustrated in Figure 1. The framework depicts that boredom arises from insufficient mental stimulation and diminished brain activity during driving under monotonous road conditions. This state induces sleepiness, and when the drowsiness is not adequately addressed, drivers are prone to microsleep. Subsequently, microsleep directly leads to a decline in driving performance. Thus, boredom exerts an indirect effect on driving performance through the occurrence of microsleep triggered by sleepiness.

This conceptual model provides the theoretical foundation for understanding how psychological factors influence the degradation of driver performance. To operationalize these constructs, the study employs the Boredom Proneness Scale (BPS) originally developed by Farmer and Sundberg [21] and subsequently refined by Struk, Carriere, Cheyne, and Danckert [22] to assess individuals' susceptibility to boredom. Meanwhile, the Epworth Sleepiness Scale (ESS) introduced by Johns [23] is used to measure levels of daytime sleepiness. Both instruments have been extensively validated in transportation psychology research and are widely recognized as reliable measures for identifying psychological factors that affect driver behavior and performance. In this study, the application of these instruments follows the methodological approach adopted by Moorjani and Putranto [24].

The novelty of this study lies in its integration of cognitive-emotional mechanisms into the analysis of transportation safety. While previous research has predominantly focused on physiological fatigue and sleep deprivation, this study advances the field by establishing a sequential model linking boredom, sleepiness, and microsleep as psychological precursors to impaired driving performance. Moreover, this study highlights cognitive-emotional mechanisms within monotonous driving contexts in Aceh, offering region-specific insights into psychological fatigue and driver safety.

Research Methodology

In this study, the research subject are drivers who have travelled the Banda Aceh - Medan route, whether using the expressways or national road. The sample size taken is 310 respondents, determined using the formula by Hair et al. [25] where the number of respondents is based on 31 indicators multiplied by 10, resulting in 310 respondents. The sampling technique used is stratified sampling, selecting drivers according to the research subject. The sample consists of 145 drivers using the expressways and 165 drivers using the national roads. This aims to explore the differences in experiences between these two groups of drivers.

There are three variables used in this study: Level of Boredom (X1) and Level of Drowsiness (X2) as exogenous latent variables, and Frequency of Microsleep (Y) as the endogenous latent variable. These three variables are further divided into sub-variables with their respective indicators. This study was previously conducted by Moorjani and Putranto [24] with the same variables, which showed a relationship between three latent variables: Boredom Proneness (BP), Epworth Sleepiness Scale (ESS), and Microsleep (MS). However, in this study, research subject focused on drivers traveling the Banda Aceh–Medan route.

For all three variables, measurements were conducted using a four-point Likert scale. The weighting of this scale was also employed to determine the drivers' tendencies by categorizing them according to gender, age, driving duration, and route type. This categorization aims to identify the levels of tendency/severity and the frequency associated with each variable among the drivers. Table 1 presents the categories of boredom levels and sleepiness levels based on the number of indicators and the four-point Likert scale.

Table 1. Categories of boredom and drowsiness levels

Variable	Indicators	Category			
		Very Low	Low	Moderate	High
Boredom Level	18	18	19-36	37-54	55-72
Drowsiness Level	8	8	9-16	17-24	25-32

The data were analyzed using the Structural Equation Modelling (SEM) method. SEM is used to examine causal relationships between complex variables in this study [26-27]. In this study, model evaluation was conducted using several Goodness of Fit (GOF) indices, which are statistical measures used to assess how well the SEM model corresponds to the observed data. The GOF indices employed in this research, along with their recommended cut-off values, are presented in Table 2.

Table 2. Goodness of fit indices and recommended cut-off values

Gof Indeks	Variable	Cut of Value
GFI	The adjusted goodness of fit	≥0.90 (good), 0.85–0.90 (marginal)
AGFI	The adjusted goodness of fit index	≥0.90 (good), 0.85–0.90 (marginal)
RMSEA	The root mean square error of approximation	0.05–0.08 (good), 0.08–0.10 (acceptable/marginal)
CFI	The comparative fit index	≥0.90 (good), 0.85–0.90 (marginal)

In Structural Equation Modelling (SEM) analysis, the term loading factor is commonly used. The loading factor value indicates the level of correlation between an indicator and its construct. The higher the loading factor value, the better the indicator represents the construct being measured. Generally, the desired loading factor value is > 0.7. If the loading factor value is below this threshold, the indicator is considered suboptimal in the measurement model [27]. Additionally, in SEM, the positive (+) or negative (-) sign in parameter estimates, such as path coefficients or loading factors, provides important information about the direction of relationships between variables.

Before building the Structural Equation Modelling (SEM) model, data quality checks were conducted to ensure that the data used meets statistical assumptions and does not exhibit abnormal distribution. Univariate outlier detection was performed by identifying Z-scores, with the criterion that Z-score values must fall within the range of $-3 \leq Z \leq 3$. Values outside this range are considered outliers. It was found that several indicators showed univariate outliers, as detailed in the Table 3.

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Table 3. Details of univariate outlier data (Z-Score) in indicator variables

Variable	Outliers		Sample
	Z-Score	Score	
Y1	3.653	4	36, 61, 236, 261
Y2	3.315	5	36, 112, 125, 165, 236
Y3	3.561	4	84, 107, 125, 284
Y4	3.165	4	61, 125, 175, 261
Y5	3.205	2	125, 165

The data from these samples has been removed from the dataset for each relevant indicator (Y1 to Y5). This step was taken because the Z-Score values of these samples exceeded the outlier threshold of 3, indicating that the values deviated significantly from the mean.

A multivariate outlier check was performed by calculating the Mahalanobis Distance. The Mahalanobis Distance was computed for each sample and compared against the critical Chi-Square (X^2) value at a specific significance level, with degrees of freedom equal to the number of variables. In this case, with 31 variables, samples with values exceeding 61.098 were identified. Therefore, these samples were removed from the dataset until no outliers remained.

Results and Discussions

The following presents the descriptive analysis results regarding the tendency/severity level and frequency of Boredom Proneness (BP) and drowsiness among drivers who have traveled the Banda Aceh–Medan route, as shown in Table 4.

Table 4. Results of Goodness of Fit (GOF) test on the model

Type	Criteria	N	BP	ESS	MS
Gender	Male	160	42.500	11.863	7.844
	Female	150	38.531	13.013	7.667
	Difference		3.969	1.151	0.177
Age	17–40	267	41.618	12.640	7.944
	>40	43	38.209	13.488	8.023
	Difference		3.409	0.848	0.079
Route Type	Expressway	145	40.581	15.909	8.667
	Non-Expressway	165	38.500	11.338	7.743
	Difference		2.081	4.751	0.924
Driving Time	Night (19:00–23:59)	81	42.852	13.654	8.259
	Midnight/Early Morning (00:00–05:00)	33	43.455	15.909	8.667
	Morning (05:01–10:59)	105	40.581	11.400	7.743
	Afternoon (11:00–14:59)	65	42.477	11.338	7.662
	Evening (15:00–18:59)	26	38.500	15.000	7.654

The descriptive analysis of Boredom Proneness (BP), Epworth Sleepiness Scale (ESS), and Microsleep (MS) among drivers who traveled the Banda Aceh–Medan route shows clear patterns related to gender, age, route type, and driving time. Overall, male drivers tend to have higher boredom levels (BP = 42.50) than female drivers (BP = 38.53), while female drivers show slightly higher drowsiness (ESS = 13.01 vs. 11.86) and similar microsleep scores (MS = 7.67 vs. 7.84). Younger drivers aged 17–40 exhibit higher boredom (BP = 41.62) compared to drivers over 40 (BP = 38.21), whereas older drivers show slightly higher sleepiness and microsleep scores (ESS = 13.49 vs. 12.64; MS = 8.02 vs. 7.94).

Drivers on expressways experience higher boredom, drowsiness, and microsleep (BP = 40.58; ESS = 15.91; MS = 8.67) than those on non-expressway routes (BP = 38.50; ESS = 11.34; MS = 7.74), likely due to the monotonous nature of long highway driving. Driving time also affects these variables, with the highest boredom, sleepiness, and microsleep observed during midnight to early morning hours (BP = 43.46; ESS = 15.91; MS = 8.67). Nighttime (19:00–23:59) and afternoon drivers also show moderate levels, while morning and evening drivers generally report lower scores. These results indicate that boredom is more pronounced among younger and male drivers, whereas drowsiness and microsleep tend to be higher among older drivers, female drivers, those traveling on expressways, and those driving during late-night hours. The findings emphasize the importance of monitoring driver alertness and implementing rest breaks during long trips, particularly on highways and during late-night travel.

After the dataset was adjusted by removing outliers, the next step was to perform path diagram modelling using the Confirmatory Factor Analysis (CFA) approach. However, the initial results indicated that most indicators did not meet the Goodness of Fit (GOF) criteria, suggesting that the model did not adequately fit the collected data. Therefore, model modification was carried out using the highest Modification Indices (MI) as a reference. This modification involved removing indicators with low loading factors and adjusting the relationships between latent variables and error terms to improve model fit.

In Table 5, the results of the model fit evaluation after modification are presented. Most of the indicators used to assess Goodness of Fit (GOF) meet the recommended criteria from the literature, demonstrating an improved fit compared to the initial model before modification.

Table 5. Results of Goodness of Fit (GOF) test on the model

Goodness of Fit	Test Results	Remarks
RMSEA	0.079	Good Fit
GFI	0.850	Marginal Fit
AGFI	0.813	Marginal Fit
CFI	0.842	Marginal Fit

The final refined model is presented in Figure 2, illustrating the structure of latent variable relationships after adjustments based on the SEM analysis results. The measurement model aims to evaluate the relationships between latent variables and their indicators. Most of the indicators in the latent construct groups of this study show significant weights in the tested model. This is indicated by the factor loading values that meet the statistical significance criteria, with t-values > 1.96, suggesting that each indicator makes a strong contribution to

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measuring the modeled latent variables. The results of the measurement model calibration, performed using the CFA approach, are presented in detail in Table 6, showing that all indicators in the table meet the criteria with significant factor loadings (≥ 0.5) and t-values far exceeding the minimum threshold of 1.96. This demonstrates that these indicators significantly represent the latent variables BP (Boredom Proneness), ESS (Epworth Sleepiness), and MS (Microsleep).

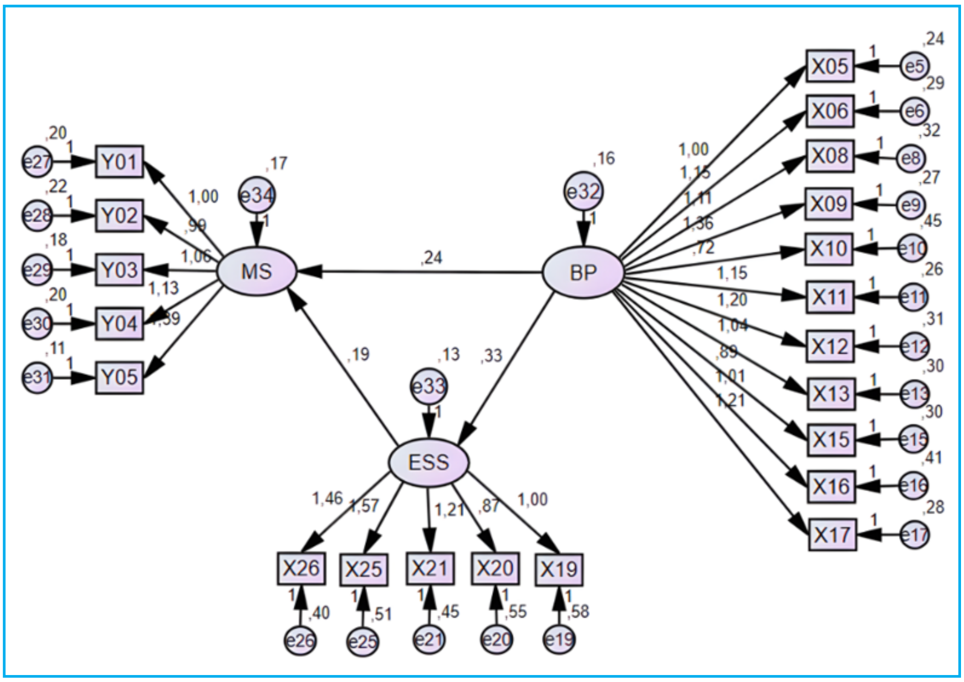

Figure 2. Path diagram modelling of Confirmatory Factor Analysis (CFA)

The analyzed model illustrates the relationships between three main latent variables: Boredom Proneness (BP), the Epworth Sleepiness Scale (ESS), and Microsleep (MS). This is evident from the estimation values, which indicate the magnitude of influence between two variables and provide insight into the direction (positive/negative) and intensity of the effects. This can be illustrated as shown in Figure 3.

All relationships in the model are statistically significant. This can be seen more clearly in the Table 7. The Structural Equation Modeling (SEM) analysis revealed that Boredom Proneness (BP) had a significant effect on the Epworth Sleepiness Scale (ESS), with a coefficient of β = 0.329 (p < 0.001). In addition, BP exerted a direct influence on Microsleep (MS), with β = 0.242 (p = 0.003). Furthermore, ESS was found to affect MS with β = 0.191 (p = 0.042). These findings align with the initial hypotheses, underscoring that boredom not only elevates drowsiness but also directly triggers microsleep episodes while driving.

This result is consistent with Moorjani and Putranto [24], who identified a relationship between boredom, drowsiness, and microsleep. Similarly, Peiris et al. [15] emphasized that monotonous conditions can suppress brain activity, thereby increasing drowsiness. Osmun [18] also highlighted that microsleep induced by drowsiness is directly associated with a heightened risk of accidents.

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Table 6. Results of measurement model

Note		Path	Estimate	t-value
BP	X05	Watching someone's home videos or travel photos makes me feel bored.	1.000	
	X06	The things I do are repetitive and monotonous	1.148	9.345
	X08	I rarely feel excited about doing my job.	1.110	8.775
	X09	Most of my time is spent doing nothing.	1.357	10.111
	X10	I find it difficult to make time for leisure.	0.725	5.917
	X11	In situations where I have to wait, like in queues, I become very restless.	1.146	9.578
	X12	It would be very hard for me to find a job that is interesting enough.	1.204	9.185
	X13	I feel that I work below my capabilities almost all the time.	1.037	8.753
	X15	It takes a lot of change and variety to make me truly happy.	0.891	7.946
	X16	TV shows or movies in cinemas seem so dull and outdated.	1.012	7.958
	X17	When I was younger, I often found myself in monotonous	1.214	9.600
ESS	X19	Reading while sitting	1.000	
	X20	Watching TV	0.872	4.658
	X21	Sitting inactive in public places (e.g., in a cinema or during a meeting)	1.208	5.539
	X25	Sitting quietly after lunch without consuming alcohol	1.566	5.796
	X26	Being stuck in traffic in a vehicle	1.458	5.826
MS	Y1	I have experienced microsleep while driving in traffic congestion.	1.000	
	Y2	I have experienced microsleep while driving on long, straight roads without obstacles (such as highways and intercity roads).	0.986	10.436
	Y3	I have experienced microsleep while driving very early in the morning	1.063	11.299
	Y4	I have experienced microsleep while driving late at night.	1.129	10.767
	Y5	I have experienced microsleep while driving for more than one hour without taking a break or a stopover.	1.292	12.085

From a practical standpoint, the findings indicate that each one standard deviation increase in boredom (BP) raises sleepiness (ESS) scores by 0.329 standard deviations. This effect is critical for road safety, as drowsiness has been shown to significantly increase the likelihood of microsleep, with $\beta = 0.191$. When compared with Moorjani & Putranto [24], the coefficient of $\beta = 0.485$ between ESS and MS suggests that increased drowsiness may elevate the risk of microsleep by nearly 50%.

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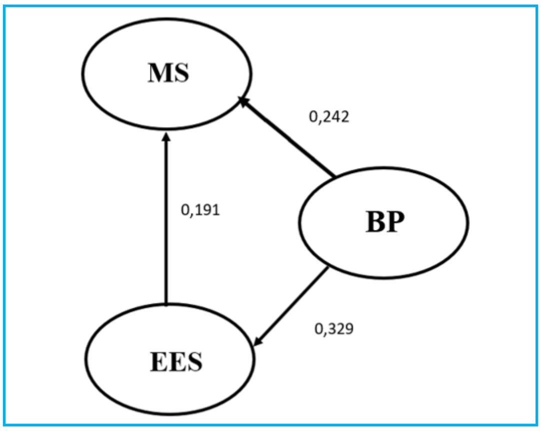

Figure 3. Relationships between latent variables and their coefficients

Table 7. The effect between variables

Relationship	Estimate	C.R	P-Value
BP → ESS	0.329	3.845	< 0.001
BP → MS	0.242	2.994	0.003
ESS → MS	0.191	2.003	0.042

The findings are highly relevant to the context of Aceh. The Banda Aceh–Medan corridor is characterized by long, straight, and monotonous road segments, heightening the risk of boredom and drowsiness among intercity drivers. The scarcity of designated rest areas, particularly along toll sections exacerbates this risk, as drivers have limited opportunities to stop and rest. Interestingly, Aceh's local culture, in which drivers frequently take breaks at roadside coffee stalls, serves as a form of "natural countermeasure" against boredom. Nevertheless, this practice remains only partially effective, as not all drivers adopt it as a deliberate rest strategy.

From a traffic engineering perspective, the results highlight the need for roadway designs that ensure not only structural safety but also sustained driver vigilance. Examples include the use of varied road geometry, periodic warning signs, and rumble strips as supplementary stimuli to maintain driver concentration. The findings further emphasize the importance of integrating in-vehicle drowsiness detection technologies, particularly for long-haul freight drivers and intercity bus operators who frequently travel along the Banda Aceh–Medan route.

Conclusions

This study highlights that psychological factors such as boredom proneness and drowsiness have a significant influence on the occurrence of microsleep while driving, which can increase the risk of traffic accidents. In the context of roads with monotonous characteristics, this condition becomes even more relevant, as drivers are more vulnerable to reduced alertness due to an unstimulating driving environment. Until now, transportation safety approaches have primarily focused on physical or technical factors, such as fatigue, road infrastructure, and vehicle conditions. Therefore, greater attention to the psychological aspects of drivers needs to be an integral part of transportation safety strategies.

The provision of adequate rest areas, the installation of warning signs along extended road segments, the application of rumble strips, and the integration of in-vehicle drowsiness detection technologies represent practical measures to mitigate the risk of microsleep. In addition, educating drivers about the dangers of boredom and the importance of regular rest is particularly relevant for high-risk corridors such as the Banda Aceh–Medan route.

As the data in this study were obtained through self-report measures, the potential for perceptual bias cannot be entirely ruled out, and the findings cannot yet be generalized to regions with different roadway characteristics. Therefore, future research is recommended to employ biometric methods such as EEG, heart rate monitoring, or eye-tracking to validate questionnaire-based results. Experimental studies using driving simulators, as well as comparative research across multiple regions, are also necessary to provide a more accurate depiction of microsleep dynamics and to broaden the understanding of boredom's role in transportation safety.

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Conflicts of Interest

All authors declare that they have no conflict of interests.

Author Contributions

Faiza Mauladea: methodology, calculation, investigation, writing- original draft preparation. **Yusria Darma:** conceptualization, data curation, supervision, writing – review & editing. **Sofyan M. Saleh:** conceptualization, visualization, supervision. **Suhana Koting:** supervision, writing – review & editing.

Data Availability Statement

The data used to support the findings of this study are included within the article.

References

[1] D. Riad, R. Anggraini, and S. M. Saleh, "Laik fungsi jalan dalam mewujudkan jalan yang berkeselamatan," J. Tek. Sipil Univ. Syiah Kuala, vol. 6, no. 3, pp. 261–270, 2017.

[2] I. M. Meilinda, S. Sugiarto, S. M. Saleh, A. Achmad, and A. Abubakar, “Driving stress partial model considering time domain applying for two wheelers drivers: A case of primary arterial roads,” E3S Web Conf., vol. 476, p. 01043, 2024. doi: http://dx.doi.org/10.1051/e3sconf/202447601043

[3] T. Kumala, R. Anggraini, and S. M. Saleh, “Analisis perilaku pengendara sepeda motor terhadap kesadaran dalam berkendara pada Jalan Laksamana Malahayati Kecamatan Baitussalam Kabupaten Aceh Besar,” J. Civ. Eng. Student, 2022. doi: http://dx.doi.org/10.24815/journalces.v4i3.13026

[4] KorlantasPolri, “Laporan kecelakaan lalu lintas Indonesia,” KorlantasPolri.Ntmc, 2024. [Online]. Available: https://x.com/NTMCLantasPolri/status/1760939454234235189

[5] Antara News, “Ditlantas catat 304 kecelakaan lalu lintas di Aceh pada Maret 2024,” Antara News Aceh, 2024. [Online]. Available: https://aceh.antaranews.com/berita/356985/ditlantas-catat-304-kecelakaan-lalu-lintas-di-aceh-pada-maret-2024

[6] H. Fithra, S. Hasyim, S. M. Saleh, and J. Saputra, “Road network connectivity and freight transportation for supporting the development of the northern zone of Aceh,” J. Southwest Jiaotong Univ., vol. 54, no. 3, p. 28, 2019.

[7] R. Anggraini, Y. Darma, M. Isya, S. A. Azan, and A. Rahmad, “Identification of black spot locations concerning the equivalent accident number and upper control limit methods: A case study of national highways in Banda Aceh, Indonesia,” AIP Conf. Proc., vol. 2711, no. 1, p. 070008, 2023. doi: http://dx.doi.org/10.1063/5.0138042

[8] H. Fusian, Y. Darma, and M. Isya, “Road safety analysis of black spot area: A case study of Banda Aceh–Medan Road section in Caleue Indrajaya subdistrict of Pidie Regency,” AIP Conf. Proc., vol. 2711, no. 1, p. 070018, 2023. doi: 10.1063/5.0137453

[9] IndoJayaNews.com, “Dirlantas: kecelakaan di Leupung diduga karena sopir mengantuk, satu meninggal dunia,” IndoJayaNews, 2021. [Online]. Available: https://www.indojayanews.com/peristiwa/dirlantas-kecelakaan-di-leupung-diduga-karena-sopir-mengantuk-satu-meninggal-dunia/

[10] I. Radun, Fatigue driving: Prevalence, risk factors, and groups, and the law, Ph.D. dissertation, Univ. of Helsinki, Finland, 2009.

[11] National Sleep Foundation, Extreme Sleepiness. Washington, DC: National Sleep Foundation, 2011. [Online]. Available: http://www.sleepfoundation.org/article/sleep-related-problems/idiopathic-hypersomnia-and-sleep

[12] B. Warssamo, “Assessing the relationship between knowledge, attitude, and practice toward Hepatitis C Virus among medical waste handlers in Sidama, Ethiopia: A structural equation modeling approach,” Perioper. Care Oper. Room Manag., p. 100558, 2025. doi: http://dx.doi.org/10.1016/j.pcorm.2025.100558

[13] T. Lees, T. Chalmers, D. Burton, E. Zilberg, T. Penzel, and S. Lal, “Psychophysiology of monotonous driving, fatigue and sleepiness in train and non-professional drivers: Driver safety implications,” Behav. Sci. (Basel), vol. 13, no. 10, p. 788, 2023. doi: http://dx.doi.org/10.3390/bs13100788

[14] G. Prajitna, Pengaruh Boredom Proneness dan Locus of Control terhadap Kecepatan saat Mengemudi di Jabodetabek, Bachelor’s thesis, Faculty of Engineering, Tarumanagara University, 2021. doi: http://dx.doi.org/10.24912/jmts.v0i0.10474

[15] M. T. R. Peiris, R. D. Jones, P. R. Davidson, and P. J. Bones, "Detecting behavioural microsleeps from EEG power spectra," in Proc. IEEE Eng. Med. Biol. Soc. Conf., New York: IEEE, 2006, pp. 5723–5726. doi: http://dx.doi.org/10.1109/IEMBS.2006.260411

[16] S. Kass, J. Wallace, and S. Vodanovich, "Boredom proneness and sleep disorders as predictors of adult attention deficit scores," J. Atten. Disord., vol. 7, no. 2, pp. 83–91, 2003. doi: http://dx.doi.org/10.1177/108705470300700202

[17] J. Wallace, S. Vodanovich, and B. Restino, "Predicting cognitive failures from boredom proneness and daytime sleepiness scores: An investigation within military and undergraduate samples," Pers. Individ. Differ., vol. 34, no. 4, pp. 635–644, 2003.

[18] R. Osmun, "Microsleep and the mind: what's happening and why," Amerisleep Blog, 2024. [Online]. Available: https://amerisleep.com/blog/microsleep/

[19] American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets, 7th ed., Washington, DC: AASHTO, 2018.

[20] M. Lombard, "Direct and interactive effects of boredom proneness, gender, and demand on reactions to interactive media," Commun. Res., vol. 22, no. 1, pp. 46–72, 1995.

[21] R. Farmer and N. D. Sundberg, "Boredom proneness: The development and correlates of a new scale," J. Pers. Assess., vol. 50, no. 1, pp. 4–17, 1986.

[22] A. A. Struk, J. S. A. Carriere, J. A. Cheyne, and J. Danckert, "A short boredom proneness scale: Development and psychometric properties," Assessment, vol. 24, no. 3, pp. 346–359, 2015. doi: http://dx.doi.org/10.1177/1073191115609996

[23] M. Johns, "A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale," Sleep, vol. 14, no. 6, pp. 540–545, 1991.

[24] A. I. Moorjani and L. S. Putranto, "Hubungan antara rawan bosan dan kemudahan tertidur dengan microsleep saat mengemudi," J. Mitra Tek. Sipil, vol. 4, no. 3, pp. 729–736, 2021.

[25] J. F. Hair, W. Black, and B. Babin, Multivariate Data Analysis, 8th ed. Andover, UK: Cengage, 2019.

[26] Z. Putlely, A. Lesnussa, A. Z. Wattimena, and M. Y. Matdoan, "Structural equation modeling (SEM) untuk mengukur pengaruh pelayanan, harga, dan keselamatan terhadap tingkat kepuasan pengguna jasa angkutan umum selama pandemi Covid-19 di Kota Ambon," Indones. J. Appl. Stat., vol. 4, no. 1, 2021. doi: http://dx.doi.org/10.13057/ijas.v4i1.45784

[27] I. Ghozali, Multivariate Analysis Application Using IBM SPSS 23 Program, 8th ed. Semarang, Indonesia: Universitas Diponegoro Publishing Agency, 2016.

https://doi.org/10.70028/dcea.v2i2.71