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Assessing Risk Factors for Driving Safety: The Role of Sleep Quality and Driving Experience Among Occupational Bus Drivers in Singapore

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Abstract

Background: Driving safety is influenced by a variety of sociodemographic and lifestyle factors such as age, health and driving experience. This study investigates these factors using a comprehensive driving safety questionnaire to assess their association with risky driving behaviours and accidents/traffic violations among professional bus drivers in Singapore.

Methods: A structured questionnaire is administered to professional bus drivers (n = 121) to evaluate their self-reported driving behaviours, attitudes, anger levels, and defensive driving techniques using validated scales and questionnaires, including the Driving Behaviour Questionnaire (DBQ), Driving Attitude Questionnaire (DAQ), Driving Anger Scale (DAS), and self-designed defensive driving measures. Additional variables such as sleep quality, weekly driving distance, and demographic information are also collected. The reliability and validity of the questionnaire are assessed and correlation analysis are conducted to examine the relations between risk factors and accident involvement/traffic violations.

Results: The questionnaire exhibits strong internal consistency (Cronbach's $\alpha > .7$) and demonstrates construct suitability for factor analysis (KMO $> .6$, BTS $p < .001$). Correlation analysis identifies poor sleep quality, measured by the Pittsburgh Sleep Quality Index (PSQI), as a primary

risk factor, showing positive associations with risky driving behaviours, heightened anger, and a greater likelihood of traffic violations. In contrast, weekly driving distance, interpreted as a measure of workload, displays negative correlations with risky attitudes and anger. This may indicate that more experienced drivers, who tend to accumulate higher mileage, develop safer attitudes and demonstrate stricter self-regulation.

Conclusions: This study identifies poor sleep quality as a critical risk factor for risky driving behaviours and traffic violations. The findings support targeted interventions to improve sleep hygiene for enhancing road safety. Despite demonstrating good reliability, further validation of the questionnaire's construct validity is recommended.

Keywords: Driving Safety; Driving Behaviour Questionnaire; Risk Factors; Correlation Analysis.

I. Introduction

Driving safety is one of the most critical concerns in road traffic management worldwide. Despite advances in vehicle technology, road infrastructure, and traffic regulations, traffic-related accidents continue to claim the lives of millions each year [33]. In particular, road traffic incidents are often caused by a combination of factors, including drivers, road conditions, and vehicle performance [11], among which risky driving behaviours of drivers, such as speeding, dangerous overtaking, distracted driving, are identified as the most significant contributors [25]. Thus, understanding the risk factors, such as sociodemographic characteristics and psychological and behavioural traits, that influence individuals to engage in these violations is crucial for developing preventive strategies.

Despite substantial research in identifying and investigating the risk factors associated with

on-road accidents and violations, considerable variation remains in how these factors influence driving behaviours that lead to these consequences across different populations and contexts. In this paper, we focus on several key factors identified in prior studies and evaluate their influence on driving behaviour and traffic violation, including age [20, 1, 24], workload [32], driving experience [18, 24, 28], health [8, 31] and sleep [21]. To achieve this, we use the Driving Behaviour Questionnaire (DBQ) [20] to assess driving behaviours, which captures self-reported risky behaviours and categorizes them to errors, lapses, and violations. Originally developed to measure aberrant driving behaviours, the DBQ has been extensively adapted and modified to suit diverse populations and contexts, with applications ranging from private car drivers to urban bus drivers [30, 13]. These prior studies have demonstrated the appropriateness and effectiveness of applying the DBQ to examine risky driving behaviours and provide insights into how various risk factors correlate with these behaviours.

For instance, Guého et al. [10] develop a 41-item version of DBQ that refines the behavioural categories, dividing violations into aggressive and ordinary violations and errors into dangerous, inattention, and inexperience errors. They conduct an online survey with 525 French drivers (205 males and 320 females), and collect as well the demographic information, accident history, and mobility (kilometers driven weekly). Their results indicate that younger drivers exhibit more aggressive violations, whereas older drivers are more likely to make errors due to inattention or inexperience. The study also highlights significant correlations between age, gender, mileage, DBQ scores, and accident involvement within the past five years.

In addition, Maslać et al. [15] validate a 25-item version of the DBQ for professional drivers transporting dangerous goods in Serbia, using a sample of 354 drivers aged 21 to 65 from 36 transport companies. Their version assesses ordinary violations, aggressive violations, errors, lapses,

and positive behaviours, while incorporating items on mobile phone use. Findings reveal that younger drivers are more prone to errors, whereas older drivers display more lapses. Moreover, annual mileage is positively associated with violations and errors, indicating that greater exposure to driving increases risky behaviours. Notably, drivers handling Class 9 hazardous materials report the highest rates of aggressive violations, suggesting that the nature of transported materials may exacerbate risky behaviours.

Similarly, Useche et al. [30] validate the F-DBQ (Freight Driving Behaviour Questionnaire), an 8-item adaptation tailored for long-haul drivers in Spain, with a sample of 982 drivers (mean age 48.5 years). The F-DBQ distinguishes between traffic violations (e.g., speeding, dangerous overtaking) and errors (e.g., misjudging speed, confusing road signs) to address the occupational conditions of freight drivers. This study examines the relationship between risky driving behaviours and work-related stress and fatigue, which identify that both factors significantly predict violations and errors. Fatigue is strongly linked to errors, while job stress, particularly measured through effort–reward imbalance, has the strongest overall predictive value for risky behaviours.

In the context of urban bus drivers, Li et al. [13] adapt the DBQ to develop the Urban Bus Driver Behaviour Questionnaire (UB-DBQ) in China. Their study involves 543 drivers completing a survey designed to address the unique challenges of urban bus driving, such as fixed routes and passenger safety during stops. The revised UB-DBQ, consisting of 18 items categorized into aggressive violations, ordinary violations, errors, and positive behaviours, demonstrates strong reliability (Cronbach's alpha: 0.83). Results show that aggressive violations, including hostile reactions to road users, are positively correlated with injury incidents involving older passengers, while positive driving behaviours are inversely related. Logistic regression analysis reveals that a higher frequency of aggressive violations increases the likelihood of injury incidents by 127%,

whereas better self-assessed safety reduces the risk by 82%.

Building on this line of research, we aim to further investigate the relation between the identified risk factors, risky driving behaviours and accidents/traffic violations by designing a comprehensive driving safety questionnaire and conducting a survey with occupational bus drivers in Singapore. The profession of bus driving entails significant risks, as drivers face prolonged exposure to traffic alongside the challenges of long working hours, strict schedules, and navigating complex urban landscapes. While research in various countries has examined the driving behaviours of occupational drivers, studies focusing on the specific cultural and traffic conditions in Singapore are notably lacking. To the best of our knowledge, no comprehensive research has yet been conducted to explore the influence of these sociodemographic and lifestyle factors on the driving behaviours of Singaporean occupational drivers. This study addresses this research gap by providing insights into the driving behaviours of Singaporean bus drivers and identifying the key factors that contribute to risky behaviours and on-road violations. Specifically, we adopt well-established questionnaires and scales and adapt the content to fit Singapore's specific traffic cli mate. For factors not adequately addressed in prior research or without suitable questionnaire or scale for evaluation, we develop new questionnaire items for their assessment. These sub-questionnaires and sub-scales are then integrated with an adapted version of the DBQ to to form a comprehensive instrument, which is detailed in Section II..

Following the questionnaire design, we conduct an in-person survey among occupational bus drivers from our collaborating bus operating company in Singapore. Using responses collected from over 100 participants, we validate our driving safety questionnaire by examining the inter-rater reliability, internal consistency and suitability for factor analysis for each sub-questionnaire/scale. Subsequently, we perform a correlation analysis to identify key risk factors associated with risky

driving behaviour and traffic violation.

Our results suggest that the comprehensive questionnaire demonstrates high internal reliability (Cronbach's $\alpha > .7$) and is deemed appropriate for factor analysis, as evidenced by satisfactory KMO values ($> .6$) and significant Bartlett's Test of Sphericity results ($p < .001$). The findings from our analysis reveal that among all the studied factors, poor sleep quality is a significant risk factor, exhibiting positive correlations with risky driving behaviours, elevated anger levels, and a higher incidence of traffic violations. Weekly driving distance, considered a measure of workload, displays negative correlations with risky attitudes and anger, indicating that more experienced drivers, who tend to accumulate higher mileage, may develop safer attitudes and demonstrate greater self-regulation. As such, the our study provides insight into preventing risky driving behaviours and traffic violations and lays the foundation for improving transportation safety, especially in modern urban cities such as Singapore.

The main contributions of this paper are two-fold:

1. We design and validate a comprehensive questionnaire. Our questionnaire combines a couple of well-established questionnaires and scales to investigate a wide range of underlying risk factors that may affect driving behaviours.

2. The results of our study fills in the knowledge gap on the subjective perception on driving behaviours of occupational fleet drivers based in Singapore. We identify the most common influential factors for risky driving behaviours among the study population including sleep quality, driving anger and defensive driving techniques. Such knowledge is fundamental yet crucial for improving transportation safety.

The remainder of this paper is organized as follows. In Section II., we explain how the adopted

sub-questionnaires and scales are modified and how the comprehensive questionnaire is designed. In Section III., we introduce the study population and procedures, as well as the analysis methods. In Section IV., we present our analysis results, focusing on the validation of the designed questionnaire and identification of the relevant risk factors. Then, we further discuss our key findings and compare our study paradigm and results with relevant studies in Section V.. Finally, we conclude this paper in Section VI..

II. Driving safety questionnaire

Before we start the design of the questionnaire, we conduct a preliminary interview among a small group of subjects (n = 6) from the target study population. The primary objective of this interview is to understand subjects' concerns and difficulties in their daily driving. From this preliminary survey, we have gained prior knowledge about their health-related problems and common scenarios when they are engaging in risky driving behaviours. We have taken into account these knowledge when we design the questionnaire. As such, our driving safety questionnaire is designed to comprehensively investigate the identified risk factors, risky driving behaviours, and traffic violations. While the instrument has been tailored to address the circumstances of professional bus drivers based in Singapore, its scope and adaptability also make it applicable to broader driver populations.

Specifically, our questionnaire consists of 147 questions in seven parts, which requires 25 to 30 minuted to complete. The details of each part are presented as follows.

1) Demographic information: The first part includes basic demographic questions about age and education level, which can be characterized by a single close ended question. Questions about

gender, nationality, and ethnicity are also included to provide more insights about the study population.

2) Sleep quality and health: The second part includes the Pittsburgh Sleep Quality Index (PSQI) and questions about health. Specifically, we adopt the PSQI to characterize subjects' sleep quality, which returns a score from 0 (best) to 21 (worst). The original PSQI is developed by Buysse et al. [3] and is a widely used questionnaire in psychiatric clinical practice and research activities that assesses sleep quality and disturbances over a one-month period. We adopt all 24 items from the original PSQI with the following two modifications. For the five questions which require rating by the bed partner or roommate, we ask subjects to fill in their self-perceived answers if they do not have a bed partner/roommate or cannot check with their bed partner/roommate during the in-person questionnaire survey. For question 6 which is about subjective sleep quality, we use a seven-point Likert scale instead of four-point to get more diverse responses. Additionally, for the assessment of health status, we develop our own questionnaire, which has two questions to assess self-perceived health, two questions to assess smoking history, two questions to assess drinking history, one question to assess frequency of being late for meals, one question to assess common health conditions including diabetes, cardiovascular disease, obesity, sleep apnea, and depression, and one question to assess the involvement in physical exercises. We design this part specifically for professional bus drivers by creating questions about important measurements suggested by prior research including smoking, alcohol use, overweight, cardiovascular diseases, perceived health [5] and common health-related problems among subjects from the target fleet including often late for meals and lack of physical exercises.

3) Driving experience, accident involvement and weekly workload: The third part is related to the driving experience, accident involvement, and weekly workload. Specifically, the driving

experience is characterized by both the time since first obtain a driving license and the duration of professional driving experience. Accident involvement includes accidents encountered and traffic tickets received over the past two years. Weekly workload is characterized by the driving distance for work per week and will be used to justify their higher exposure to traffic compared to private car drivers (see Section A.).

4) Driving behaviour: The shortened (38-item) DBQ is adopted in part IV to assess driving behaviours such as distracted driving, and intentional violation. Items 10 (Attempt driving off in third), 12 (Locked out of car), 14 (Drive as fast on dipped lights), 17 (Forget where car is), 24 (Forget which gear), 31 (Forget tax/insurance expiry), 35 (Drink and drive), 38 (Illegal parking), 42 (Plan route badly), 45 (Cut comer turning right), 48 (Fail to give way to bus), and 52 (Drive wrong way down one-way street) from the original DBQ are removed because the scenario is either not applicable to public bus drivers or not applicable to Singapore's road design and traffic climate. One item, "Drive with only 'half-an-eye' on the road while communicating with commuters", is added because it is a very frequent scenario during bus driver's daily operations. All questions in this part are in a seven-point Likert scale format from 1 to 7 with 1 being very rare or not happened and 7 being very frequent.

5) Driving attitude: In part V, we adopt a shortened 16-item Driver Attitude Questionnaire (DAQ) to assess perceptions on the commission of violations including speeding, close following (i.e., tailgating), drink driving and dangerous overtaking with each behaviour assessed by 4 items. The original DAQ [17] is a self-report questionnaire that requires respondents to indicate their agreement with statements about the aforementioned behaviours. All questions in this part are in a seven-point Likert scale format from 1 to 7 with 1 being strongly disagree and 7 being strongly agree.

6) Driving anger: In part VI, we adopt the 33-item Driving Anger Scale (DAS) [7] to characterize driving anger. The original DAS is developed by Deffenbacher et al. [7] to assess the propensity to become angry in situations of traffic obstruction, illegal driving, slow driving, police presence, hostile gestures, and discourtesy. All questions in this part are in a seven-point Likert scale format from 1 to 7 with 1 being not angry at all and 7 being extremely angry.

7) Defensive driving: In part VII, a self-designed 20-item Defensive Driving Questionnaire (DDQ) about defensive driving is developed to assess the driver's driving techniques and mindset in avoiding potential accidents. This scale mainly assess three types of defensive driving techniques, namely proper speed control (items 131 to 133, 135, 136, 142 and 147), maintaining safe distance (items 127 to 130, and 138), and keeping lookout for other road users (items 137, 139 to 141, and 143 to 146). Items in this part represent specific scenarios under different traffic conditions (e.g., "Drive with high speed when there are few vehicles on the roads"). All questions in this part are in a seven-point Likert scale format from 1 to 7 with 1 being very rare or not happened and 7 being very frequent.

To ensure the validity of the questionnaire data, we design two criteria to filter out invalid responses. The first is a trap question for item 134, "If you are reading the questionnaire carefully, please indicate 7 for this question", for which we intentionally ask subjects to select 7. Any completed questionnaire with any other answers for this item will be labelled as invalid. The second criterion is there are at least 2 unique choices among the 21 items in the "Defensive Driving" section. Because question 131 "Drive with slower speed during bad weather" and 132 "Drive with slower speed during traffic jam" are arranged in reverse Likert scale where a higher rating would indicate more appropriate behaviour, while all the remaining questions in the "Defensive Driving" section are in the opposite order (e.g., "Fail to stay fully concentrated at the end of a long shift",

"Forget to check for upcoming vehicles when there is construction on one side of the road"), we assume that any valid and consistent response would have different answers to items 131 and 132 and the remaining questions. The aim of the second criterion is to filter out subjects who do not read through the questions and choose 7 for all the items.

Because the target study population mainly consists of drivers from Singapore, Malaysia and China, who comprehend either written Chinese or English, both English and Chinese version of this questionnaire is prepared by experienced researchers (i.e., authors of this work) with good proficiency in both Chinese and English. The questionnaire is first translated into Chinese by a native Chinese speaker who is proficient in spoken and written English. Then in line with the methodology recommended by pertinent studies [35, 2], the Chinese version is translated back into English and is revised according to the inconsistency between the original and translated English version. This process is iteratively undertaken multiple times to guarantee the precision of the translation.

III. Study population and procedures

In this Section, we first describe the study population and procedures, following by explaining the data analysis method and the successful criterion or threshold for each specific test.

A. Study population

As introduced, we target at professional bus drivers based in Singapore for this cross-sectional study. There are in total 121 subjects recruited for the study from a local public bus operator, which constitute over 15% of the total number of bus drivers in this company. The inclusion criteria are being an occupational public bus driver and being able to comprehend written English

or Chinese. Among all the subjects, 119 manage to complete the questionnaire, and 102 (Male: 96, Female: 6) provide valid responses (exclusion criteria are introduced in Section II.). All these 102 responses are further analyzed to validate our questionnaire and identify significant risk factors.

B. Study procedures

As aforementioned, this study uses a paper-based questionnaire for data collection in the form of an in-person survey. Such study design has no known risk or discomfort to research subjects. During the initial planning of the study, a preliminary interview is first conducted (see details in Section II.) to gather opinions from bus drivers on potential factors affecting their driving behaviour, which facilitates the design of a comprehensive questionnaire. The study is approved by the Institutional Review Board of Nanyang Technological University, where the authors of this work are affiliated with, and assigned with the IRB reference number: IRB-2020-06-006. Before the commencement of the study, subjects are informed about the purpose of the study and the voluntary basis of their participation. We ensure subjects understand the format and content of each item on the questionnaire through one-on-one briefings. Consequently, written consent is obtained from all subjects by signing the informed consent forms. Particularly, we have emphasized the confidentiality and anonymity of their responses to minimize social desirability biases and peer influences. We then assign the paper-based questionnaire to each subject and facilitate them in completing the survey study by answering their questions.

C. Data analysis plan

The data analysis has two primary objectives. The first objective is to validate the self-designed driving safety questionnaire by conducting reliability and validity tests for each sub-scale and ques-

Table 1 Health Status Scoring Criteria

Score	Self-Perceived Health	Smoking History (yrs)	Drinking History (yrs)	Late for Meals	Health Conditions*	Physical Exercise
0	7	0	0	Never	0	>2 times a week
1	5	0-5	0-5	Sometimes	1	1-2 times a week
2	3	6-10	6-10	Often	2-3	<once a week
3	1	>10	>10	Always	>3	<once a month

*: health conditions include diabetes, cardiovascular disease, obesity, sleep apnea, and depression

tionnaire (i.e., DBQ, DAQ, DAS, and DDQ). Specifically, inter-rater reliability is assessed using Cohen's kappa, where a value of 1 indicates perfect agreement, and a value of 0 indicates no agreement at all. Additionally, the internal consistency of each component is measured using Cronbach's α, with thresholds of 0.65, 0.70, and 0.80 representing minimally acceptable, respectable, and excellent consistency, respectively [9]. In addition, the data suitability for factor analysis is also tested for future exploratory factor analysis by the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity (BTS). The KMO test returns values in the range from 0 to 1, and values greater than .6 suggest suitable correlations between items for factor analysis [22], while the BTS with p value less than .001 also suggest that the dataset is suitable for factor analysis [26].

The second objective is to identify risk factors associated with on-road accident and traffic violations. To achieve this, we first calculate scores for the PSQI and our short health questionnaire. For the PSQI, we convert the seven-point Likert scale to a four-point scale and follow the scoring instructions in [3] to compute a final score ranging from 0 (best) to 21 (worst), representing the overall sleep quality of participants. Similarly, the overall health score is calculated based on the scoring criteria in Table 1, with a range of 0 (best) to 18 (worst). Subsequently, we conduct normality tests using the Kolmogorov-Smirnov and Shapiro-Wilk tests for all variables to choose between Pearson and Spearman correlation coefficient for the correlation analysis.

Table 2 Statistical Distribution of Demographic, Driving Experience & Accident/Traffic Violation

		Male		Female
Gender		96 (94.12%)		6 (5.88%)
		CN	MY	Others
Ethnicity		88	10	4
	SG	CN	MY	PK
Nationality	31	34	36	1
	min	max	mean	std
Age	24	71	46.98	9.41
Driving Experience (years)	4	53	24.12	10.03
Professioanl Experience (years)	3	46	16.47	9.29
PSQI Score (0-21)	2	14.5	6.31	2.42
Health Score (0-18)	0	13	5.84	2.86
Weekly Driving Distance (km)	45	3000	663	434
Accidents Involved	0	6	0.58	0.94
Tickets Received	0	2	0.03	0.17

SG - Singaporean, CN - Chinese, MY - Malaysian, PK - Pakistanis

IV. Results

In this Section, we first present the results of descriptive statistics of simple factors including demographics, health, sleep quality, driving experience, weekly driving distance and accident history. Then, we show the reliability and validity tests for separated sections of the questionnaire, following by the results of correlation analysis between potential risk factors, risky driving behaviours and on-road accident involvement/traffic violation.

A. Descriptive statistics

The descriptive statistics of demographics, health, sleep quality, driving experience, weekly driving distance and accident history are shown in Table A.. The average age of the 102 subjects is 46.98 years (min: 24, max: 71) with a standard deviation of 9.41. The male to female ratio is 16:1. The age distribution and male to female ratio follow the general gender and age distribution in the entire fleet. The majority of subjects in the study are of Chinese ethnicity, accounting for 86.27% of the sample, followed by Malay ethnicity at 9.80%. This distribution generally aligns with the overall

ethnic distribution in Singapore, with Chinese ratio slightly higher than in the overall resident population (Chinese: 3.02 million, 74.12%; Malay: 0.55 million, 13.6%) [27]. In terms of driving experience, subjects have an average professional driving experience of 16.47 years with a standard deviation of 9.29 (min = 3, max = 46). Because relevant studies in the literature categorize subjects as either novice or experienced using a 3-year threshold [24], all subjects can be considered as experienced driver regarding this standard. Additionally, the average PSQI score of 6.31 indicates good overall sleep quality and the average health score of 5.84 indicates good overall health level (a higher score indicates poorer sleep quality/health status). Furthermore, the weekly driving distance indicates subjects' exposure to road traffic e nvironment. The average driving distance of 663 km per week is comparable with the statistics of professional drivers in similar studies. For instance, Davey et al. [6] report annual driving distance of 30,000 to 40,000 km (576.92 to 769.23 km per week) for 443 fleet drivers in A ustralia. Tseng [29] reports less than 30,000 km per year (576.92 km per week) for 308 tour bus drivers, 30,000 to 59,999 km (576.92 to 1153.85 km per week) for 918, and over 60,000 km per year for 797 tour bus drivers. Such driving distances are significantly longer than private car drivers. Chu et al. [4] report 16,640 km per year (320 km per week) for 887 drivers in China. Li et al. [12] report more than 50 km but less than 400 km a week for 411 drivers. The annual and weekly driving distance in [34] are even less, only 10,435 km per year (200.69 km per week) for 449 drivers. Such statistics are solid evidences for professional drivers' elevated exposure to traffic. R egarding a ccident i nvolvement a nd t raffic vi olation, th e average accidents involved in the past two years over the entire sample is only 0.58, with 61 subjects having no accident record and 30 subjects involving in only one accident. The number of subjects who have received traffic tickets is even less. Only two subjects received one ticket and one subject received two tickets in the past two years. The total accident involvement of 59 over 41 subjects

Table 3 Reliability and Sampling Adequacy

Section	κ	α	KMO	BTS's p value
Driving Behaviour	.044	.905	.760	$<$.001
Driving Attitude	.139	.662	.624	$<$.001
Driving Anger	.033	.970	.927	$<$.001
Defensive Driving	.182	.756	.694	$<$.001

κ - Cohen's kappa, α - Cronbach's alpha

(40.20% of total study population) and traffic tickets of three over three subjects (2.94% of total study population) show comparable accident rate and significant lower ticket rate compared to relevant studies [14, 16, 28]. Lastly, we decide to exclude education level from our analysis due to the diverse responses from participants, who come from different countries (i.e., Malaysia, China, Singapore, etc.) with different educational systems.

B. Validation of questionnaire

The Cohen's kappa (κ), Cronbach's alpha (α), the KMO and BTS's p value for driving behaviour, attitude, anger and defensive driving section are presented in Table 3. The low Cohen's kappa values, which fall below .2, indicate only slight agreement in the responses across the fours sections of the questionnaire (i.e., driving behaviour, attitude, anger, and defensive driving). This suggests that participants, even within the same bus company and after receiving the same safety training, exhibit considerable diversity in their self-reported behaviours and attitudes. This variability could be attributed to several factors, such as individual differences in driving experiences, personal interpretation of safety-related concepts, or differences in how subjects perceive or recall their behaviours. Additionally, despite the uniform safety training, personal attitudes and driving styles often reflect a complex interplay of cognitive, emotional, and environmental factors that may not be fully captured through self-report measures. Such diversity, while reducing the level of agreement, highlights the need for further exploration into the unique factors influencing each participant's

driving behaviour. Moreover, the Cronbach's α coefficients exceeding .7 for the driving behaviour, anger, and defensive driving sections suggest good internal consistency. While some studies have used .7 as the threshold for this coefficient [23], a lower acceptable threshold of .65 has also been reported in relevant literature [19], so we deem the internal consistency for the attitude section acceptable as well. In addition, the KMO values exceeding .6 and BTS p values less than .001 indicate that our data is suitable for factor analysis.

In summary, the reliability and validity measures confirm the robustness of our questionnaire. While the low Cohen's kappa values indicate diversity in participants' self-reported behaviors, the Cronbach's α coefficients exceeding .7 for the driving behavior, anger, and defensive driving sections demonstrate good internal consistency. Furthermore, the KMO values above .6 and statistically significant BTS ($p < .001$) confirm the suitability of the data for factor analysis, supporting the structural validity of the questionnaire.

C. Correlation analysis

In this subsection, we present the correlation analysis among the identified risk factors, risky driving behaviour, and accident involvement/traffic violation. Because the results of normality tests (both Kolmogorov-Smirnov and Shapiro-Wilk) indicate a non-normal distribution of our questionnaire data, we use the nonparametric method, Spearman's correlation, to investigate the correlation between underlying risk factors and driving behaviour and the correlation between driving behaviour and on-road accidents, respectively.

The correlation between subjects' age, health, sleep quality, professional driving experience, weekly driving distance, and accident involvement (i.e., number of traffic tickets received and number of accidents reported), the average score of driving attitude, anger, and defensive driving

Table 4 Correlation Between Risk Factors, Sub-questionnaires and Accident Involvement/Traffic Violation

Dependent Variable	Independent Variable	Correlation (ρ)	p-value
DBQ Average	Age	-.1728	.0823
DBQ Average	Experience	-.0443	.6584
DBQ Average	**Weekly Distance**	**-.2331**	**.0184**
DBQ Average	**PSQI Score**	**.2710**	**.0059**
DBQ Average	Health Score	.0740	.4599
DAQ Average	Age	-.0898	.3225
DAQ Average	Experience	-.0298	.7660
DAQ Average	**Weekly Distance**	**-.3039**	**.0019**
DAQ Average	PSQI Score	.1582	.1122
DAQ Average	Health Score	.1149	.2502
DAS Average	Age	-.1323	.1849
DAS Average	Experience	.0742	.4587
DAS Average	**Weekly Distance**	**-.2892**	**.0032**
DAS Average	**PSQI Score**	**.2169**	**.0286**
DAS Average	Health Score	.1233	.2171
DDQ Average	**Age**	**.1963**	**.0480**
DDQ Average	Experience	-.1687	.0902
DDQ Average	Weekly Distance	.1631	.1014
DDQ Average	PSQI Score	.0324	.7464
DDQ Average	Health Score	-.0290	.7727
Self-Reported Accidents	Age	.0204	.8390
Self-Reported Accidents	Experience	-.0280	.7801
Self-Reported Accidents	Weekly Distance	-.0851	.3950
Self-Reported Accidents	PSQI Score	.1107	.2679
Self-Reported Accidents	Health Score	.1079	.2802
Traffic Tickets	Age	-.0802	.4231
Traffic Tickets	Experience	-.0511	.6099
Traffic Tickets	Weekly Distance	-.1592	.1099
Traffic Tickets	**PSQI Score**	**.2552**	**.0096**
Traffic Tickets	Health Score	-.0719	.4724

are reported in Table 4. Significant (both significant at 0.05 level and 0.01 level) correlations coefficients are highlighted in bold. First, the average score of DBQ shows a significant negative correlation with weekly driving distance (Spearman's ρ = -.233, p = .0184), suggesting that drivers who travel longer distances tend to report lower levels of risky driving behaviours. Additionally, a positive correlation is observed between DBQ average and PSQI score (Spearman's ρ = .271, p = .0059), indicating that poorer sleep quality is associated with higher levels of self-perceived risky

Table 5 Correlation Between Sub-questionnaires and Accident Involvement/Traffic Violation

Dependent Variable	Independent Variable	Correlation (ρ)	p-value
Accidents	DBQ Average	.1650	.0975
Accidents	DAQ Average	.1473	.1394
Accidents	DAS Average	.0384	.7017
Accidents	DDQ Average	-.1733	.0815
Traffic Tickets	DBQ Average	.0957	.3385
Traffic Tickets	DAQ Average	.0118	.9060
Traffic Tickets	DAS Average	.0197	.8441
Traffic Tickets	DDQ Average	-.0069	.9451

driving behaviours. For the average score of DAQ, a significant negative correlation is found with weekly driving distance (Spearman's ρ = -.304, p = .0019), implying that drivers who travel longer distances weekly tend to more positive driving attitudes, potentially indicating more experienced or more regulated driving behaviour over time. Similarly, the average score of DAS shows a significant negative correlation with weekly driving distance (Spearman's ρ = -.289, p = .0032), suggesting that drivers who accumulate more weekly miles tend to report less anger while driving. A positive correlation between DAS average and PSQI score (Spearman's ρ = .217, p = .0286) indicates that higher levels of driving anger are associated with poorer sleep quality, pointing to a potential link between emotional regulation and sleep patterns. The Defensive Driving scores correlate positively with age (Spearman's ρ = .196, p = .048), suggesting that older drivers tend to have better practice of defensive driving behaviours, possibly due to increased driving experience and risk awareness. Lastly, the number of traffic tickets shows a significant positive correlation with PSQI score (Spearman's ρ = .255, p = .0096), indicating that drivers with poorer sleep quality are more likely to accumulate traffic tickets, likely due to impaired attention, reaction time, and decision-making associated with inadequate sleep.

Moreover, as shown in Table 5, when treated as independent variables, none of the average scores of DBQ, DAQ, DAS, and DDQ show a significant correlation with the number of traffic tick-

ets or reported accidents. This suggests that self-reported behaviours, attitudes, anger levels, and defensive driving techniques may not directly correspond with actual road violations or accident occurrences.

In summary, the correlation analysis highlights the key risk factors influencing driving behaviours as follows. Poor sleep quality, as measured by the PSQI, is significantly associated with higher levels of risky driving behaviours, more frequent traffic tickets, and greater driving anger. Weekly driving distance, while interpreted as a measure of workload, also serves as an indicator of driving experience, with higher mileage reflecting accumulated expertise rather than solely increased workload. This suggests that longer driving hours are also linked to enhanced familiarity and confidence on the road. Additionally, older drivers are more likely to engage in defensive driving behaviours, reflecting a greater sense of risk awareness and experience.

V. Discussion

This study aims to investigate the relation between various risk factors identified from prior studies and driving behaviours, focusing on self-reported measures including DBQ, DAQ, DAS, DDQ, and objective indicators like weekly driving distance, sleep quality, and driving experience. Based on the data collected from bus drivers, we validate our driving safety questionnaire by evaluating the inter-rater reliability and internal consistency. Furthermore, the findings from the correlation analysis provide valuable insights into how these factors interact and influence driving behaviour and on-road accident involvement.

A. *Validation of the Questionnaire*

Specifically, we conduct validation of our driving safety questionnaire with a primary focus on assessing the internal consistency of sub-questionnaires and scales. The Cronbach's α coefficients demonstrate strong internal consistency for the adopted DBQ, DAS, and our self-designed DDQ. While the adopted DAQ exhibits a slightly lower alpha coefficient of .662, we consider its internal consistency as acceptable for two key reasons. Firstly, the DAQ is a well-established questionnaire that we adopted without any modifications. Secondly, it's worth noting that a lower threshold of .65 has also been utilized in previous studies [19], further supporting our decision.

B. *Key Risk Factors: Sleep Quality*

The correlation analysis highlights a significant association between sleep quality and traffic violations, as higher PSQI scores (i.e., poorer sleep quality) are linked to a greater number of traffic tickets received. This relationship can be partly attributed to the positive correlations between PSQI scores and self-reported risky driving behaviours as well as elevated levels of driving anger. These findings align with existing literature, which suggests that inadequate sleep impairs cognitive functions such as attention, reaction time, and decision-making [21], all of which are essential for safe driving. Drivers with poorer sleep quality may therefore be more susceptible to engaging in risky behaviours, experiencing heightened emotional responses such as road rage, and committing traffic violations.

Weekly driving distance, interpreted as a measure of workload, demonstrates significant negative correlations with self-reported risky driving behaviours, incorrect driving attitudes, and heightened driving anger. However, since these self-reported measures do not correlate with actual traffic violations or accident involvement, the observed relationships may instead reflect improved safety

awareness and stricter self-regulation among more experienced drivers who accumulate higher mileage.

Given these findings, improving sleep quality emerges as a critical intervention to reduce risky driving behaviours and traffic violations. Public health campaigns emphasizing the impact of sleep quality on driving performance could help raise awareness and mitigate fatigue-related risks. Additionally, educating drivers about the importance of maintaining good sleep hygiene and providing resources for managing sleep disorders may contribute to safer driving behaviours, particularly among those who frequently operate under high workloads or extended driving hours.

VI. Conclusion

In this paper, we introduce a comprehensive driving safety questionnaire designed to investigate the sociodemographic and lifestyle factors influencing driving safety. The results from bus drivers based in Singapore highlight poor sleep quality as a critical risk factor, showing significant associations with risky driving behaviours, heightened anger, and an increased likelihood of traffic violations. Additionally, weekly driving distance, interpreted as a measure of workload, demonstrated negative correlations with self-reported risky attitudes and anger, suggesting that more experienced drivers may adopt safer attitudes and stricter self-regulation despite driving longer hours. These findings underscore the importance of interventions focused on improving sleep hygiene to enhance road safety. However, this study is limited by its reliance on self-reported data, which may be subject to biases such as social desirability and recall inaccuracies. Future research should incorporate objective measures of driving performance and conduct further assessments of the questionnaire's construct validity to enhance the robustness and generalizability of the findings.

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