

Article

Aberrant Driver Behavior, Poor Sleep, Fatigue Among Bus Rapid Transit Drivers and Sustainable Traffic Safety

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Abstract

A great deal of effort has been made to investigate and develop approaches to address driver behavior, fatigue, and sleepiness for different road users worldwide. However, very little research has been conducted to explore these issues in the context of Bus Rapid Transit (BRT) drivers in a low-income countries such as Mexico. The present study fills this gap. The aim of this study is to identify the human factors contributing to aberrant driver behavior (ADB) among BRT professional drivers in Mexico City. A total of 152 drivers participated in a self-reported survey. Exploratory factor analysis was performed on the BRT-ADBQ to identify the behavioral factors, and the Checklist Individual Strength (CIS-Fatigue) subscale was employed to assess the fatigue of drivers. The key findings were the following: (a) the created BRT-ABDQ identified two ADBs (violations and errors); (b) violations factors, but not errors, contributed to accident involvement; (c) ADB, fatigue, poor sleep and age (30–39) were predictors to accidents and (d) a linear trend has been revealed indicating that as the hours of sleep decreased, the experience of fatigue increased proportionally. The conclusion of the study is that ADB, sleepiness, and fatigue are real and existent among BRT drivers and should be a matter of concern for the case of the BRT organization that participated in the study. More generally, organizations running these systems should intervene by implementing sleep and fatigue reduction strategies to mitigate the adverse impact of these and thereby contribute to sustainable traffic safety and urban mobility.

Keywords: aberrant driver behavior; fatigue; sleepiness; professional drivers; Bus Rapid Transit; sustainable traffic safety; urban mobility

1. Introduction

According to the World Health Organization (WHO) there were approximately 1.19 million deaths on the road in 2021 across the world, a 5% drop compared to the 1.25 million deaths in 2010 [1]. However, the Sustainable Development Goals road safety target which aimed to halve the number of global deaths and injuries from road traffic accidents by 2020 has not been met [1]. More worryingly, in low-income countries, not only has the target not been met, but deaths and injuries from road traffic accidents are on the rise. The WHO report also presents the percentage of fatalities for different road users, e.g., motorcyclists and other powered two- and three-wheeler riders (30%), occupants of four-wheeled vehicles (25%), pedestrians (21%), cyclists (5%), vehicles carrying more than 10 people, heavy goods vehicles and “other” users constitute 19% of deaths.

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In a similar vein, the European Agency for Safety and Health at Work [2] reported that professional drivers are faced with high risk of death/injury in road traffic accidents since most of their working time is spent on the road, and that 85.2% of accidents are linked to human errors. Similar findings have been reported that professional drivers are involved in more road accidents than non-professional drivers [3]. Hence, it is essential to study the relationship between the driving behaviors of public transport professional drivers and road crashes, especially in urban environments.

1.1. Fatigue and Sleepiness

In general, the terms “fatigue” and “sleepiness” are generally used interchangeably; however, there is a distinction between the two terms in the scientific literature. “Sleepiness” is defined as the physiological urge to fall asleep, usually resulting from sleep loss [4], whereas “fatigue” has been defined as the inability to continue a task or activity because it has been going on for too long [5], “an experience of tiredness, dislike of present activity, and unwillingness to continue” [6], or as a “disinclination to continue performing the task at hand and a progressive withdrawal of attention” from environmental demands [7]. Overall, fatigue may be characterized by subjective sleepiness, changes in psychological state, reduced performance and alertness, and difficulties with sustained attention [8].

Previous research has identified fatigue as a contributing factor to road traffic crashes in the transport sector [9–12]. It has also been reported that one of the main causes of fatigue is attentional lapses due to insufficient sleep [13,14]. Other factors include prolonged wakefulness, disruptions to circadian rhythms, and sleep disorders [9], as well as the time spent on tasks [8]. However, there is no published research on the subject regarding professional BRT drivers globally and in the context of the present case study.

The aforementioned raises the question as to how to measure fatigue? The published literature has shown that it can be measured objectively and subjectively [15]. Objective fatigue measures address physiological processes or performance such as reaction time or number of errors [16]. Subjective measures to fatigue assessment include approaches such as interviews, questionnaires or scales. Some of the most common include the Fatigue Scale (FS) [17], the World Health Organization Quality of Life assessment instrument [18], the Need for Recovery Scale (NRS) [16], the Fatigue Assessment Scale (FAS) [19], and the Checklist Individual Strength Scale (CIS-20) [20]. In the present work, the CIS-20 has been adopted for the analysis (see Section 3.4).

Sleepiness or difficulty staying awake represents a major hazard that compromises safety in many industries, including the transport sector. Occupational bus drivers are characterized by shift work, and consequently drivers are likely to experience sleepiness at work. For example, a study on urban bus drivers found that 19% had to fight to stay awake at least 2–3 times a week [21]. Another study found that most of the drivers experienced severe sleepiness while driving at least 2–4 times a month [22]. Previous research has also shown that shift schedules contribute directly to crash risk [23].

1.2. The Driver Behavior Questionnaire (DBQ)

A considerable amount of research has been conducted aiming at better understanding the relationship between driver behavior and road traffic crash involvement [24–34]. The Manchester Driver Behavior Questionnaire (DBQ) may be regarded as the most used framework for investigating this relationship [24]. The self-reported DBQ initially was developed to distinguish between two empirically different classes of “aberrant driver behavior”, defined as “the departure of driving behavior from standard driving, required for the vehicle’s safe operation.” This includes traffic violations (unintended, deliberate), errors (slips and lapses, mistakes), and distraction. Violations are defined as “deliberate deviations from those practices believed necessary to maintain the safe operations of a

potentially hazardous system" [24], e.g., exceeding the speed limit, following another vehicle too closely, among others. Errors, on the other hand, are defined as the "failure of planned actions to achieve their desired outcome without the intervention of some chance or unforeseeable agency" [25], e.g., braking too quickly on a slippery road, among others. Driving errors are the result of information processing problems, whereas violations have a large motivational and social component [24,25].

In recent years, "positive" driving behaviors have been found necessary in DBQ [26,35,36]. "Positive" driving behavior refers to the behavior that does not take codes, rules, regulations, and safety into major consideration, instead, it prefers to concern the traffic environment and other drivers, and it is willing to aid and maintain politeness while driving [36]. For example, "keep a safe following distance so as not to affect the preceding vehicles", among others.

The DBQ has been employed to study driver behaviors of different modes of road transport such as long-haul truck drivers [33,37], motor car drivers [38], train drivers [39], airline pilots [40], tram drivers [41], and occupational drivers (taxis, buses, trucks, construction vehicles) [13,42], and motorbike riders [30,43], and only two studies have been published explicitly on professional Bus Rapid Transit (BRT) drivers [26,44]. Further, it has been reported that professional drivers are subjected to higher work-related stress, fatigue, higher mileage, tight schedule, well designated routes, shift schedules, among others, than non-professional drivers [23,44,45]. Hence, these adverse working conditions increase the risk of being involved in accidents.

Unlike other modes of public transport systems, the BRT system has unique and very distinctive characteristics in the context of Mexico City, such as the following (see Appendix A for further details): BRT transports an average 1.2 million users per day; BRT operates in dedicated transit lanes; BRT vehicles can be bi-articulated (with a capacity for 240 passengers) and double-decker (capacity for 130 passengers), with low-floor and multiple double-wide doors; they provide fast and frequent service and stops spacing of a few hundreds of meters, around 1 km and more than 1 km. Overall, BRT professional drivers work under very stressful conditions to deliver a quality service to the users, i.e., they should drive fast and provide a reliable service. Therefore, users and road safety are of paramount importance in urban environments.

The review presented in the section can be summarized with the following two highly publicized events that occurred in Mexico City [46], which, in a way, were part of the motivation of the study: (a) on 27 August 2024, a BRT bus collided with over ten motor cars while allegedly over-speeding; it is believed that the BRT driver was asleep and passed the red light and collided with these vehicles. Several people were injured because of the road accident and (b) on 8 November 2024, a metro driver was caught on video apparently falling asleep (or being drunk) while driving and the video went viral on social media; luckily there were no adverse consequences.

Finally, the present study fulfills the existing gap by examining the factors influencing the aberrant driver behavior (ADB) among BRT drivers by using the DBQ. To accomplish the aim of the study, a BRT-ADBQ was developed in an attempt to understand BRT drivers' behavior of a BRT line operator in Mexico City. The study addressed the following research questions:

- RQ1: What is the underlying factor structure of the BRT–Aberrant Driver Behavior Questionnaire (BRT-ADBQ)? Past research suggests either a two- or three-factor structure (violation, error, positive). Is the structure of the BRT-ADBQ in the present study, using a BRT operator sample, consistent with this previous research?
- RQ2: What aberrant driver behavior factors predict the likelihood that BRT drivers would report that they have been involved in an accident?

- RQ3: Is there a difference in BRT drivers' fatigue scores for <4, 4–6, and 6–8 h of sleep per night?
- RQ4: How well does subjective fatigue predict accident involvement?

The paper is organized as follows. Section 2 describes the materials and methods employed in the analysis, including the employed survey questionnaire, data collection, and a brief description of the statistical methods employed in the analysis of the collected data, e.g., the employment of a binary logistic regression to determine the contributory factors leading to crash involvement. Section 3 presents the details of the main results of the analysis. A discussion of the main findings, limitations, and areas for future research are presented in Section 4. Finally, Section 5 presents the main conclusions and findings of the study.

2. Materials and Methods

2.1. Participants and Data Collection

One BRT operator was invited to take part in the study, the sample was for convenience, and all the participants were male drivers (i.e., currently there is quite a few female drivers, but most are males in the whole BRT network system). Drivers were asked to voluntarily complete the BRT–Aberrant Driver Behavior Questionnaire (BRT-ADBQ). Ethical review and approval were waived for this study due to the use of fully anonymized data collection through voluntary participation. The study involved no collection of personally identifiable information, and verbally informed consent was obtained from all participants prior to completing the questionnaire. According to current national and institutional regulations (e.g., Regulations of the General Health Law on Health Research, the Official Gazette of the Federation (Ministry of the Interior)), formal ethics committee approval was not required for minimal-risk studies that do not involve identifiable data. Data were collected from August 2024 to January 2025 and were anonymized and de-identified with no personal information, and confidentiality was ensured.

2.2. Measures

2.2.1. The BRT–Aberrant Driver Behavior Questionnaire (BRT-ADBQ)

As already mentioned in Section 1, there are not many studies on the unsafe driving behavior of BRT drivers. In addition to the available literature on driver behavior [24,25,27,28,47,48], the questionnaire employed in the present analysis is based on two studies such as those being conducted on BRT driver behaviors [26,44]. Furthermore, the final version of the developed questionnaire received some input of the key findings of BRT accident analyses conducted by the authors. For example, drivers violating traffic rules in several congested areas in the capital city, BRT buses passing the red light, stopping temporarily on critical intersections, either BRT lanes being invaded by motorcars, motorcycles, cyclists, or BRT buses invading pedestrian/cyclist lanes, or making illegal turns, among others [46]. Hence, the following items were included in the final version of the questionnaire: “Q25. Drive especially close or flash at vehicles (cars/motorcycle/bicycle users, pedestrians) that invaded your lanes to go faster or get out of your way”, and “Q28. Invade the lane assigned to pedestrians and cyclists”. Finally, following a series of revisions and consultations with drivers, a total of 34 items were retained on the BRT-ADBQ (Table A3 in Appendix B).

The proposed 34-item DBQ was then used to collect data of BRT drivers and, in line with similar studies [26,30,49], drivers were asked to respond to each of the items on a six-point rating Likert scale, i.e., 1 = never, 2 = hardly ever, 3 = occasionally, 4 = quite often, 5 = frequently, 6 = nearly all the time.

2.2.2. BRT Drivers' Accident History

BRT drivers that participated in the study were asked to report the number of accidents they have been involved in during the last three years. The three-year period was considered based on similar studies [23,25–27,43]. In the present study, the adopted definition of accidents or crashes is the following: “events in which collision has happened resulting in injuries or vehicle damage” [26]. Before taking the responses, the research team explained to the drivers about the meaning of accidents, and the team ensured they all clearly understood it.

2.2.3. Checklist Individual Strength (CIS) Scale

Fatigue may be regarded as one of the major concerns at work. Over the years, fatigue instruments have been developed to assess it [17,19,50]. The Checklist Individual Strength (CIS) instrument is one of the most frequently used, valid and reliable instruments for measuring fatigue [51]. It has been used extensively in different populations and has been translated in several languages [52,53] including the Spanish version [53].

The instrument consists of 20 items with four dimensions, i.e., the subjective experience of fatigue (eight items) and reduction in motivation (four items), reduction in physical activity (three items), and reduction in concentration (five items). Participants were instructed to indicate how they felt during the last two weeks. The items are scored on a seven-point rating Likert scale (1 = yes, that is true, to 7 = no, that is not true). The CIS-subjective fatigue subscale (hereafter, either fatigue, subjective fatigue, or subjective experience of fatigue [15]) can be used independently and this has been the approach taken in the present study [44]. The CIS-Fatigue subscale is standardized with high internal consistency and test reliability, good discrimination and validity criterion, and the ability to detect change in subjective fatigue [51,54]. Furthermore, the fatigue subscale has also been used in the transport sector [44].

2.3. Data Analysis

Demographic characteristics of the BRT drivers were described by employing descriptive statistics. A series of *t*-tests were performed to compare ADB scores and accident involvement and demographic variables. Principal component analysis (PCA) was performed to explore the structure of the 34 BRT-ADBQ items. Cronbach's alpha reliability coefficient was used to measure the internal consistency of the BRT-ADBQ scale scores. SPSS software Version 25 was used for all statistical analyses and most of the statistical tests conducted were two-tailed, except for the one-way analysis of variance (ANOVA) between groups with planned comparisons designed to assess the difference between subjective fatigue and hours of sleep (i.e., a one-tailed statistical test). For the case of categorical data, dummy variables were created to conduct binary logistic regression (LR) analyses to predict accident occurrences. Receiving operating characteristic (ROC) analysis was performed to assess the accuracy of the LR models' accident involvement predictions. ROC curve is a graphical plot between true positive rate (sensitivity) and false negative rate (1-specificity). The area under the curve (AUC) measures the overall ability of the LR models to discriminate between accident-involved and accident-free drivers, with values closer to 1.0 indicating better performance [43,55]. All the statistical tests were performed with a statistical significance set up at $p < 0.05$.

3. Results

3.1. Demographics

Of the 155 drivers who completed the questionnaire, a total of 152 provided valid data and were thus included in the present analyses. Participants had a mean of 42.1 years

of age (standard deviation (SD) = 10.3, median (M) = 43, minimum = 20, maximum = 64, range = 44). A total of 12.5% reported having completed elementary education, around 51.0% completed a high school diploma, and 36.8% reported a college education and above (Table 1). A relatively high percentage of drivers were married (68.4%) and around 59.0% mentioned that they have been involved in crashes.

Table 1. Some demographic characteristics of the participants of the study.

Variable	Category	N	%
Age group	≤29	19	12.5
	30–39	42	27.6
	40–49	51	33.6
	≥50	40	26.3
	Total = 152		100.0
Education	Elementary	19	12.5
	Secondary	77	50.7
	College and above	56	36.8
	Total = 152		100.0
Marital status	Married	104	68.4
	Single	48	31.6
	Total = 152		100.0
Alcohol consumption [13]	Yes	74	48.7
	No	78	51.3
	Total = 152		100.0
Driving experience (years)	<4	104	68.4
	5–9	34	22.4
	>10	14	9.2
	Total = 152		100.0
Hours of sleep (h) [27]	<4	27	17.8
	4–6	94	61.8
	6–8	31	20.4
	Total = 152		100.0
Self-reported accidents	Yes	89	58.6
	No	63	41.4
	Total = 152		100.0

Data on the drivers' overall health (e.g., diabetes mellitus, hypertension, body mass index (BMI), acute/chronic sleep, among others), lifestyle (quantity of alcohol consumption, smoking, among others), and working conditions (mileage, yearly income, working shifts, among others) were not available for the present study (i.e., data were requested but not given). Hence, the criteria used by similar studies regarding drivers' hours of sleep [13] and alcohol use [27] were adopted in the study. (See the limitations and future work in Section 4.4.)

The subjective fatigue subscale item scores are shown in Table 2. The highest item score is seen in item 1 ("I feel tired") with a median score 5.0 (IQR 3.0–7.0); this item was followed by item 4 ("Physically, I feel exhausted"), median score 4.0 (IQR 2.0–6.0). The subjective experience of the fatigue subscale had an Alpha Cronbach = 0.80.

Table 2. Subjective experience of fatigue subscale [51].

Item No.	Category	Median	IQR
1	"I feel tired"	5.0	(3.0–7.0)
4	"Physically, I feel exhausted"	4.0	(2.0–6.0)
6	"I feel fit" *	2.0	(1.0–4.0)
9	"I feel weak"	1.0	(1.0–2.0)
12	"I feel rested" *	4.0	(2.0–5.0)
14	"Physically I am in bad shape"	2.0	(1.0–5.0)
16	"I get tired very quickly"	2.0	(1.0–4.0)
20	"Physically I feel in a good shape" *	3.0	(2.0–5.0)

* Items formulated in positive terms are reverse scored to avoid response bias.

3.2. Factor Analysis

The 34 items of the BRT-ADBQ were subjected to principal component analysis (PCA) with the Varimax rotation method. Prior to performing PCA, the suitability of data for factor analysis was assessed, i.e., the strength of the interrelations among all the items considered in the analysis were assessed (Table A3). The resulting coefficients that were either less than 0.3 or greater than 0.8 were removed [55,56]. Several items were removed at this stage of the analysis (e.g., items Q2, Q3, Q4, Q18, Q19, Q24); inspection of the correlation matrix, on the other hand, revealed the presence of many coefficients of 0.3 and above. The obtained Kaiser–Meyer–Oklin (KMO) value was 0.811 (χ^2 (78, n = 152) = 585.616, p < 0.001), exceeding the recommended value of 0.6 [55,56] and Bartlett's test of Sphericity [55] reached statistical significance, supporting the factorability of the correlation matrix.

PCA revealed the presence of eight components (or factors) with eigenvalues exceeding 1, explaining 6.43%, 2.03%, 1.57%, 1.46%, 1.36%, 1.24%, 1.11% and 1.05% of the variance respectively. An inspection of the scree plot revealed a clear break after the second factor. Using Catell's [55] scree test, it was decided to retain two factors for further investigation. This was further supported by the results of the Monte Carlo parallel analysis [57], which showed only two factors with eigenvalues exceeding the corresponding criterion values for a randomly generated data matrix of the same size. Hence, a two-factor solution was adopted in the present study, and the factor analysis was again performed. The items having an absolute value of factor loading less than 0.3 and items that did not load on any of the factors were removed from further analysis as they represent a weak correlation with the factor [34]. Finally, for a 13-item BRT-ADBQ, the two-factor solution explained a total of 45.36% of the variance. Table 3 shows the 13 items on BRT-ADBQ along with factor loading and mean score for each of the items. (It should be noted that some items associated with positive driving behavior were included in the original set of items but were not loaded as a three-factor solution (e.g., Q18, Q19, Q24)).

Table 3. Principal component analysis of 34-item BRT-ADBQ (n = 152).

BRT-ADBQ Items	Mean (SD)	Components	
		1 (Error)	2 (Violations)
Q9. "Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa."	1.4803 (1.0733)	0.843	
Q11. "While driving on the road, you fall asleep and wake up to realize that you have no clear recollection of the road along which you have just travelled."	1.6053 (1.2772)	0.819	
Q12. "Lost in thought, you forget that your lights are on full beam until flashed by other drivers."	1.5263 (1.1155)	0.761	

Q10. "Misjudge your gap while parking and nearly (or actually) hit adjoining vehicle."	1.4605 (1.1032)	0.740	0.370
Q21. "Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late."	2.1250 (1.4797)	0.493	
Q28. Invade the lanes assigned to pedestrians and cyclists.	1.5329 (0.9344)	0.305	0.743
Q1. "How often do you disregard speed limit to catch up or avoid being late to bus station from bus depot."	2.2171 (1.3515)		0.626
Q29. "Invade a junction or intersection, causing a bottleneck for incoming vehicles."	1.8421 (1.3026)		0.622
Q30. Ignore "Yield" or "Stop" signs; narrowly avoiding a collision.	1.8750 (1.4526)		0.575
Q20. "Angered by another driver's behavior, you give chase with the intention of giving him/her a piece of your mind."	1.6382 (1.0582)		0.564
Q34. "Driving without a seat belt."	1.3224 (1.0007)		0.489
Q25. Drive especially close or flash at vehicles (motorcars/motorcycle/bicycle users, pedestrians) that invade your lane to go faster or get out of your way.	2.4342 (1.6823)		0.484
Q16. "Lost in thought or distracted, you fail to notice someone waiting at a zebra crossing, or a pelican crossing light that just turned red."	1.7763 (1.3480)		0.351
% of variance explained		12.00	33.36
Number of items		5	8
Cronbach α		0.801	0.707
<i>M</i>		1.6395	1.8298
<i>SD</i>		0.9097	0.7378

Factor 1 explained 12.0% of the total variance and contained five items (Q9, Q11, Q12, Q10, and Q21) having factors loading more than 0.3. All the items are related to incorrect decisions taken by BRT drivers. Most of the items were related to driver's errors (e.g., Items Q9: "Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa", Q11: "While driving on the road, you fall asleep and wake up to realize that you have no clear recollection of the road along which you have just travelled.", item Q10: "Misjudge your gap while parking and nearly (or actually) hit adjoining vehicle", among others), which are consistent with similar studies being conducted on the unsafe driving behavior of BRT drivers [26,44]. However, item Q10 was retained in component 1 given that it has a higher loading factor than in component 2 and, more importantly, it is not related to violations.

Factor 2 explained 33.36% of the total variance and contained 8 items (Q28, Q1, Q29, Q30, Q20, Q34, Q25, and Q16). All the items of factor 2 highlight violating traffic norms and regulations (e.g., items Q28. "Invade the lanes assigned to pedestrians and cyclists", Q29: "Invade a junction or intersection, causing a bottleneck for incoming vehicles", Q25: "Drive especially close or flash at vehicles (cars/motorcycle/bicycle users) that invaded your lane to go faster or get out of your way", among others). Again, these items were consistent with similar studies on BRT [26,44]. Therefore, factor 2 was termed as violations.

For error and violation factors, the Cronbach's alpha coefficients were 0.801, and 0.707, respectively. For the aberrant driving behavior (ADB), the composite score, the Cronbach's alpha coefficient was 0.81. Overall, the factors have an acceptable internal consistency. The correlation among the two factors, and the correlation between the factors and the composite score are shown in Table 4. Pearson's correlation analysis reveals that

all the components of BRT-ADBQ shared a relatively weak correlation between error and violation, thereby these factors seem to measure different constructs and represent different aspects of driving behavior [26].

Table 4. Correlation matrix between BRT-ADBQ factors and ADB (composite score).

Variable	1	2	3
1. Aberrant driver behavior	1.000		
2. Errors	0.798 **	1.000	
3. Violations	0.845 **	0.504 **	1.000

Note. ** $p < 0.01$.

3.3. Aberrant Driving Behavior and Accident Involvement

A series of *t*-tests were conducted to compare ADB (as a compound scale), violations and error factor scores across accident involvement and demographic variables. On average, drivers that were involved in accidents reported more frequent violations ($M = 0.81$, $SD = 0.48$, $t(152) = 2.622$, $p = 0.010$, Cohen's $d = 0.43$) and ADB ($M = 0.75$, $SD = 0.43$, $t(152) = 2.656$, $p = 0.009$, Cohen's $d = 0.43$) than drivers who had not been involved in accidents. However, there was no significant difference between error factor scores and drivers involved in crashes ($M = 0.70$, $SD = 0.51$) and those who had not experienced accidents ($M = 0.54$, $SD = 0.50$), $t(152) = 1.892$, $p = 0.060$, Cohen's $d = 0.31$. Finally, there was no difference between alcohol use and marital status on the self-reported frequency of violations and errors.

A binary logistic regression analysis was performed to predict the occurrence of accident involvement, and the results are shown in Table 5. Overall, the model containing the predictors was statistically significant, $\chi^2(9, 152) = 24.962$, $p < 0.05$, indicating that the model was able to distinguish between respondents who reported and did not report an accident. The model explained between 15.1% (Cox & Snell square) and 20.4% (Nagelkerke R squared) of the variance in accident occurrence status and correctly classified 66.4% of cases.

Table 5. Contribution factors to accident involvement over the last three years.

Predictor Variable	Measures	β	SE	<i>df</i>	<i>p</i>	OR	95% CI [Lower–Upper]
Error	Continuous	0.089	0.330	1	0.778	1.093	[0.572–2.087]
Violation	Continuous	0.912	0.334	1	0.008	2.490	[1.268–4.887]
Hours of sleep	<4	1.117	0.479	1	0.020	3.055	[1.194–7.816]
Age	30–39	0.607	0.415	1	0.143	1.836	[0.815–4.138]
Marital status	Married	0.624	0.386	1	0.106	1.867	[0.875–3.981]
Alcohol consumption	Yes	0.666	0.369	1	0.071	1.947	[0.945–4.012]
Experience (years)	5–9	0.676	0.490	1	0.168	1.966	[0.752–5.140]
	>10	0.567	0.458	1	0.215	1.764	[0.719–4.327]
Education	Elementary and Secondary	−0.378	0.380	1	0.319	0.685	[0.325–1.442]
Constant		−3.618	0.980	1	<0.001	0.027	

Model summary: $-2LL = 181.286$; $\chi^2 = 24.962$; $df = 9$; $p = 0.003$; Nagelkerke $R^2 = 20.4\%$; Hosmer & Lemeshow test, $p = 0.475$.

Only the violation factor and hours of sleep contributed significantly to predicting accident involvement. That is, for each one unit increase in the violations factor score the odds of being involved in a crash increase by 149% (OR = 2.49, 95% CI [1.268, 4.887]). Regarding the hours of sleep, drivers that sleep <4 h have three times the odds of being

involved in accidents compared to drivers that sleep more hours (6–8 h) (OR = 3.055, 95% CI [1.194, 7.816]). Lastly, when considering the ADB compound score, it has been found that for every one unit increase in ADB, the odds of being involved in a crash increased by 227.5% (OR = 3.275, 95% CI [1.540, 6.966]; $\beta = 1.186$, Std. Err. = 0.385, Wald = 9.491, $p < 0.01$),

3.4. Fatigue and Aberrant Driver Behavior

3.4.1. Fatigue and ADB as Predictors of Accident Involvement

A series of *t*-tests were conducted to compare subjective fatigue scores across age, accidents, and alcohol consumption. On average, drivers that were involved in accidents experienced greater feelings of fatigue ($M = 3.65$, $SD = 1.27$) than drivers who had not been involved in crashes ($M = 3.07$, $SD = 1.43$), $t(152) = 2.684$, $p = 0.008$, Cohen's $d = 0.44$. However, there was not a significant relationship between age and alcohol consumption for the subjective experience of fatigue.

A binary logistic regression analysis was performed to predict the occurrence of accidents (Table 6). Overall, the model was statistically significant, $\chi^2(3, 152) = 15.448$, $p < 0.001$, the model explained between 9.7% (Cox & Snell square) and 13.0% (Nagelkerke R squared) of the variance in accident occurrence and correctly classified 65.1% of cases. Fatigue, age, and hours of sleep made a significant contribution to the outcome. As expected, the strongest predictor of accident involvement was hours of sleep, i.e., the odds of being involved in a crash are 2.6 times higher for drivers having poor sleep compared to drivers that sleep more hours (6–8) (OR = 2.603, 95% CI [1.061, 6.385]). When considering fatigue, the results showed that for each one unit increase in fatigue score the odds of being involved in a crash increased by 43.5% (OR = 1.435, 95% CI [1.104, 1.866]). Regarding age (30–39), the odds of being involved in accidents are 2.3 times higher than older drivers (OR = 2.314, 95% CI [1.083, 4.942]).

Table 6. LR model—fatigue as a predictor of accident involvement.

Predictor Variable	Measures	β	SE	<i>df</i>	<i>p</i>	OR	95% CI [Lower–Upper]
Subjective fatigue	Continuous	0.361	0.134	1	0.007	1.435	[1.104–1.866]
Age	30–39	0.839	0.387	1	0.030	2.314	[1.083–4.942]
Hours of sleep	<4	0.957	0.458	1	0.037	2.603	[1.061–6.385]
Constant		−2.249	0.732	1	0.002	0.105	

Model summary: $-2LL = 190.800$; $\chi^2 = 15.448$; $df = 3$; $p = 0.001$; Nagelkerke $R^2 = 13.0\%$; Hosmer & Lemeshow test, $p = 0.484$.

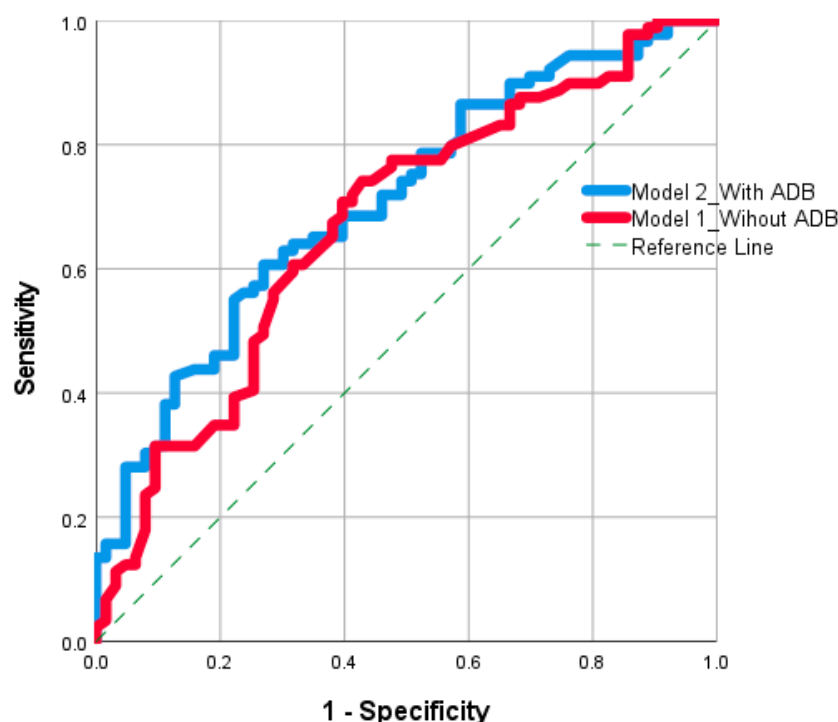
Table 7 shows the results when ADB compound scale is included in the model for accident involvement prediction. As with the previous case, subjective fatigue, ADB, age, and hours of sleep contributed significantly to the prediction of the outcome variable. For example, for each one unit increase in the ADB score the odds of being involved in an accident increased by 131% (OR = 2.311, 95% CI [1.151, 4.638]). To identify the relative importance of the subjective experience of fatigue and ADB as contributors to accident occurrence, these were standardized. As expected, the ADB has been the strongest contributor to the prediction of accidents, i.e., a one standard deviation (SD) change in the frequency of ADB increases the odds of accident involvement by a multiplicative factor of 4.803, compared with a one SD change of fatigue increasing the odds of the outcome variable by a multiplicative factor of 1.241.

Table 7. LR models for predicting accident occurrence by including ADB.

Predictor Variable	Measures	<i>p</i>	Unstandardized ¹		Standardized ²	
			β	OR	β	OR
Subjective fatigue	Continuous	0.032	0.295	1.343	0.216	1.241
ADB	Continuous	0.018	0.838	2.311	1.569	4.803
Age	30–39	0.049	0.777	2.176	0.777	2.176
Hours of sleep	<4	0.028	1.05	2.845	1.05	2.845
Constant		<0.001	−3.468	0.031	−3.468	0.031

¹ Model summary: $-2LL = 184.887$; $\chi^2 = 21.361$; $df = 4$; $p < 0.001$; Nagelkerke $R^2 = 17.7\%$; Hosmer & Lemeshow test, $p = 0.707$. ² The standardized estimates apply only to the continuous variables.

Finally, ROC curve analysis was performed for the two logistic regression models shown in Tables 6 and 7, i.e., with and without the ADB composite scores. Figure 1 shows the plot between sensitivity against 1-specificity (i.e., sensitivity is defined as the probability of correctly predicting accident-involved drivers, whereas specificity is the probability of predicting correctly drivers not involved in accidents). For model 1 (without ADB) and model 2 (with the inclusion of ADB) scores, the area under the curve (AUC) was 0.673 ($p < 0.001$, 95% CI [0.568–0.760]) and 0.708 ($p < 0.001$, 95% CI [0.626–0.790]), respectively. As expected, the results highlighted that model 2 may be regarded as acceptable in distinguishing between the drivers involved and not involved in accidents (i.e., $AUC > 0.70$).

**Figure 1.** Comparing two ROC curves for LR analysis of accident involvement (Tables 6 and 7).

3.4.2. Hours of Sleep and Subjective Experience of Fatigue

Two planned comparisons were conducted in the study (see Appendix C for further details on these): (1) a polynomial contrast aiming at finding a linear trend of the group means (i.e., 6–8 and <4 h of sleep, the code grouping was in descending order) and (2) an investigation into whether the two groups of hours of sleep made a difference to the subjective experience of fatigue.

In general, the results highlighted a significant effect of hours of sleep on drivers' subjective experience of fatigue, $F(2, 149) = 4.10$, $p < 0.05$, $\eta^2 = 0.052$. Furthermore, the analysis revealed a significant linear trend, $F(1, 149) = 5.938$, $p < 0.01$ (one-tailed), indicating that as the hours of sleep decreased, the perceived experience of fatigue increased proportionately (Figure 2).

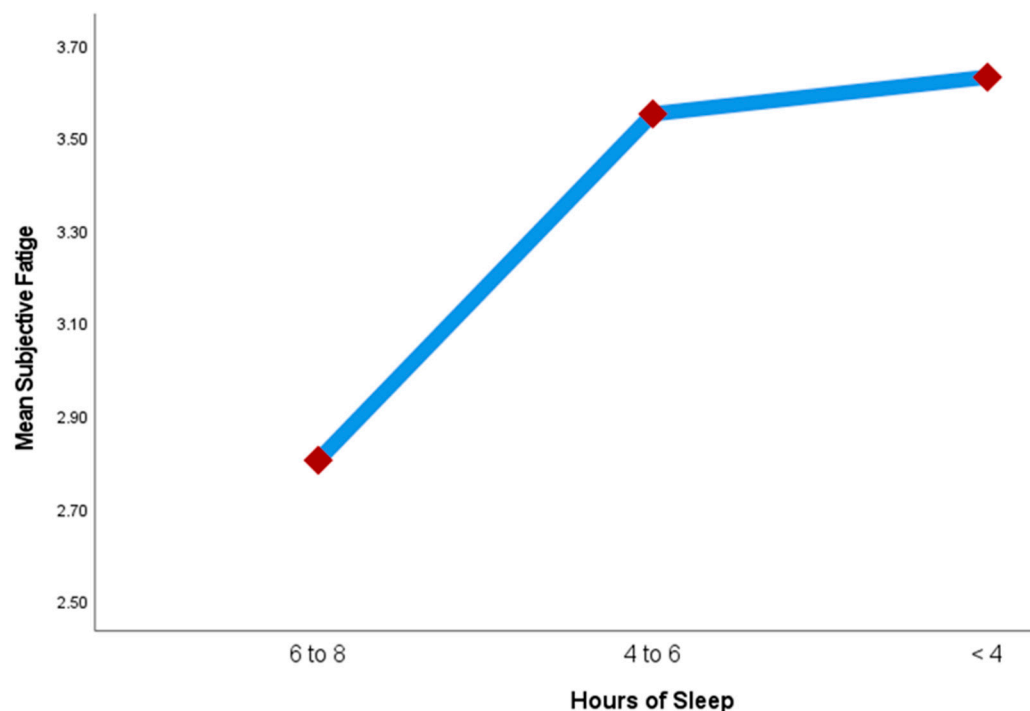


Figure 2. Linear relationship between fatigue and drivers' hours of sleep per night.

The second planned contrast, on the other hand, revealed that having <4 h of sleep significantly increased the perceived experience of fatigue compared to having more hours of sleep (i.e., 6–8), $t(149) = 2.352$, $p = 0.01$ (one-tailed), $r = 0.18$.

4. Discussion

4.1. BRT–Aberrant Driver Behavior (BRT-ADBQ)

The aim of the study was to investigate aberrant driving behavior among BRT drivers in Mexico City using a BRT-ADBQ. A total of 34 items were created and when performing an exploratory factor analysis, two aberrant driving behaviors were revealed, i.e., errors and violations (Table 3). The results are in line with similar studies [25,34,47,58–62]. Furthermore, the two-factor scale exhibited relatively good internal reliability via Cronbach's alpha coefficient. The resulting two-factor structure scale, however, differs from the findings of a similar study on the BRT system where a three-factor structure was reported, i.e., the inclusion of positive factor [26] which included the following items: "25. Avoid braking too hard considering passenger discomfort." (Q24 in the study); "26. During Bus bunching, I try to maintain significant headway with the leading bus to avoid queuing at stops."; "19. Try to keep minimum safe distance from the vehicle in front." (Q18 in the study); and "20. Try not to honk unnecessarily, so as to avoid affecting others." (Q19 in the study). In the present study, item 26 was not included in the questionnaire, items 18 and 19 were removed in the data screening phase of the analysis [55,56], items 20 and 25 were removed from the analysis given that their KMO individual items were less than the acceptable limit of 0.5 [55]. These issues may have influenced the two-factor solution.

More positive items should be included in the BRT-ADBQ in the context of the city in future research.

Another explanation may be due to the cultural differences among countries. For example, in that same study, it has been argued that over-speeding is one of the major issues in India [26], i.e., "...a higher mean score on Item 1 and 4 suggest that the BRT drivers perform over-speeding and disregard the traffic lights most of the time." (p.10). However, over-speeding may not represent a big issue in Mexico City, but road users permanently invading BRT lanes represents the biggest challenge of the current mass transit system (Appendix A). This fact forced us to re-phrase the following positive item "Try not to honk unnecessarily, so as to avoid affecting others." (Table 2, p. 6, in [26]) to "Q19. Try using your horn to alert cyclists/motorcyclists/pedestrians when invading your lane." (Table A3). The topic of cultural differences being discussed is consistent with similar studies. For example, it has been argued that "the applied DBQ version and social and cultural differences between the stated countries, the authors obtain diverse results" [35]. Similarly, a study reported that drivers from different countries and of different models might have different aberrant driving behaviors [63].

Regarding the individual item scores of the two factors, item Q25 had the highest mean score, i.e., "Drive especially close or flash at vehicles (cars/motorbike/bicycle users/pedestrians) that invaded your lane to go faster or get out of your way"). Again, this finding supports what has been mentioned in the previous paragraphs. It has been reported that one of the contributing factors of accident occurrence is the fact that motor cars, among others, invade BRT lanes, causing crashes [64]. More recently, SEMOVI (Mexico City Secretariat of Mobility) has implemented a policy aiming at preventing accidents by fining road users that invade the designated BRT lanes; the fines lie between three thousand (for the first-time offenders) and five thousand (for the recurring offenders) Mexican pesos (around 61 and 101 US Dollars, respectively). Other courses of action have also been implemented to address this problem such as the use of sensor systems, which aim to capture license plates of the offending vehicles and fine them. It is believed that since the policy implementation in 2019, there have been over a million fines among the seven BRT lines that comprise the whole BRT system in the capital city [46]. Hence, this clearly demonstrates that sustainable road safety goals have not been met in the megacity.

4.2. Aberrant Driver Behaviors and Accident Involvement

In the present study, aberrant driving behaviors (as a compound scale) and violations were significantly associated with accident involvement, but not the errors factor. The findings are consistent with previous research [25,27,29,33,59,65–67]. Some other studies, however, have found that errors, not violations, predicted accident involvement [68]. In general, there have been heterogeneous findings regarding the use of ADBQ in predicting accident involvement [26,32,36,49,58,59,68–70]. The results are also consistent with the most recent studies being conducted on BRT [71,72], buses [73] and truck drivers [74–76] where rule violations are a major contributor to traffic accidents. At present, it is unclear why errors did not contribute to accident involvement in the present case study. An explanation may be the one given in [25], i.e., "emphasizing the association between violations and accidents may oversimplify a complex picture. It may be that an important cause of accidents arises when an error is made during the course of committing a violation." (p. 1045). Another explanation has to do with the operational characteristics of the BRT corridor in the present case study. Recently, the BRT operator warned that drivers face the greatest operational difficulties across the entire system due to the conditions of the corridor that runs through the city center of the megacity [46]. In the city center, the traffic is affected all the time by the high concentration of commercial and pedestrian activity. BRT operators must drive buses up to 15 m long (Appendix A) in areas where street

vendors and established businesses, taxis, minibuses, uber, private vehicles, cargo tricycles, motorcycles, bicycle users and pedestrians converge, which generates delays, friction, incidents, and traffic accidents (e.g., “Q28. Invade the lanes assigned to pedestrians and cyclists.” and “Q25. Drive especially close or flash at vehicles (motorcars/motorcycle/bicycle users, pedestrians) that invade your lane to go faster or get out of your way.” See Table 3). This situation further aggravates during peak seasons, e.g., the BRT operator mentions that “a large part of the corridor is pedestrianized” [46]. Furthermore, drivers ask for “traffic police on the corridor-private vehicles run red lights, support (us) with (no invade BRT lane) signals, the existing ones are not visible” [46].

Lastly, another explanation may be that since drivers are under huge pressure to meet tight schedules, they consequently commit violations, e.g., items Q1, Q25, Q28. In this regard, one of the drivers mentioned that “We are required to meet the arrival times (at stations), but it is important that they (decision-makers) support us in pedestrian safety, traffic education for motorcyclists, private vehicles throughout the city center and handcart drivers (i.e., workers who transport goods such as fruits, vegetables, or similar products using two-wheeled handcarts)” [46]. In general, it may be argued that BRT drivers and other road users (pedestrians, motorcycles, motor cars) intend to reach their destinations on time, i.e., BRT drivers aim to reach the next stop on time, while other road users are in a rush to reach their destinations. To summarize, this sense of urgency leads to traffic violations and, consequently, undesirable events. Hence, to reduce accident occurrence due to commission of violations it becomes necessary, as suggested by the cited study, to improve the safety culture by changing attitudes, beliefs and norms.

However, demographic variables such as age, education, marital status, and alcohol use did not contribute significantly to accidents (Table 5). These findings are in line with similar studies, for example, age and marital status were not associated with accidents in Refs. [26,27]. A negative correlation was found between age and self-reported errors and violations [32]. Similarly, alcohol use was associated with speeding but not accidents [13].

4.3. *Fatigue, Poor Sleep and Accident Involvement*

Regarding the analysis of polynomial contrasts, the results highlighted a significant linear trend indicating that as the hours of sleep decreased, the perceived experience of fatigue increased proportionately. The findings are consistent with previous research on the nature of the relationship between poor sleep and fatigue [10,77]. For example, a study reported several factors as the cause of sleepiness including shift work, and personal factors such as obtaining less than 11 h rest between shifts, working 6 or more days without a rest day, and poor self-reported health [77]; these causal factors are not foreign to BRT drivers in the context of the present study. For example, regarding days and hours of work, a driver mentioned the following [46]: “I’d like two days off”, “(we should) Only work 8 h (according to the driver, they work more than 10 h), because dealing with passengers is annoying—Working for MB (BRT) as an operator (driver) is the most stressful job”. Then this raises the following question, do poor sleep and fatigue contribute to BRT drivers’ self-reported accidents?

The findings of the study revealed that fatigue, hours of sleep, and age contributed significantly to accident involvement, and, as expected, poor sleep was the strongest predictor. The findings are in line with similar studies being conducted on truck drivers, bus drivers, and passenger car drivers [10,12,13,38,44,74,76–79]. For example, it has been reported that sleepiness is one of the leading contributors to road accidents, accounting for 15–30% of all road crashes worldwide [38]. Hence, there is clear evidence that the quality of sleep represents a problem for city bus drivers as reported in studies being conducted in Sweden [21], the UK [77], Japan [80], and Peru [81]. Regarding driver fatigue, a study revealed that 74% of truck drivers spent 1 to 3 h of rest during their journeys and found a

significant correlation between fatigue and the frequency of accidents [11]. However, driver sleepiness and fatigue have not received attention to BRT drivers in both at an international level and in the context of Mexico City; for example, a driver that participated in the study mentioned that [46] “(we need) more time to get to the terminals... I am really pressed for (getting on) time (at stations/terminals) ... (Key-decision-makers should) consider the accidents caused by drivers falling asleep (due to poor sleep). In my 10 years of driving experience, listening to music helps with sleepiness—talking to someone else helps with sleepiness.” In fact, there are no studies addressing these issues explicitly in the published literature.

The results have also revealed that age (young adults) was a significant predictor of accidents. The finding is in line with similar studies, e.g., it has been reported that younger drivers are more prone to driving whilst sleepy [82,83] and experience greater driving impairments following sleep loss [84]. In comparison, drivers in their 40s and 50s were 50% less likely, whilst those aged between 60 and 73 were 60% less likely to accident risk [85]. Similarly, it has been reported that truck and car drivers that experienced fatigue-related incidents were younger than those who did not [85]. In the case of BRT bus drivers in the present study, those aged between 30 and 39 may have poor sleep prior to work as they may try to engage in more social activities, e.g., 33.3% were single and 45.2% reported that they consumed alcohol.

To summarize, the results of the present analysis revealed that ADB, poor sleep, age, and fatigue, contributed significantly to accident involvement. This raises the following questions: what are the implications regarding urban mobility in the capital city? Do BRT crashes occur during rush hours? Does congestion due to BRT-related accidents contribute to the increase in CO₂ emissions? Regarding urban mobility and accident occurrence, it is evident that the former is disrupted, affecting the economy of cities, among other things [86]. For example, in the USA alone, around 8.8 billion hours were lost due to traffic accidents [87]. Traffic accidents also contribute to congestion and an increase in CO₂ emissions [88]. This is clearly the case of the present study where 48.28% of BRT accidents occur within the identified three peak hours (i.e., 06:00–08:00 a.m.; 13:00–15:00 p.m.; and 17:00–0:00 p.m.) causing heavy traffic congestion [46,64]. Furthermore, given the frequency of accident occurrence, Mexico City has been considered as the most congested city in the world in two consecutive years [89]. To conclude, this is one of the major contradictions of the BRT system. That is, it was designed to run in exclusive lanes to increase speed and safety, among others, as part of a sustainable road safety policy; however, as has been demonstrated that BRT-related accidents produce a knock-on effect and compromise sustainable traffic safety in the megalopolis.

4.4. Limitations of the Study and Future Research

- First, the presented results should be taken with caution. It was a cross-sectional study with a sample for convenience; therefore, there is a possibility of bias given that participants came from one of the BRT line operators from the existing seven across the megacity; hence, the results apply only to this BRT line operator. Hence, the results should not be generalized to all the BRT drivers of the capital city. Further research aims at increasing the sample size by conducting a random sample and by considering the seven existing BRT lines operating in the megacity. It is hoped to be able to replicate the results presented herein.
- Second, some data bias, i.e., it is possible that some participants were not honest due to the fear of being dismissed or reprimanded from their employer. As such, it may be the case that the frequency of self-reported accident involvement, among others, is also an underestimation.

- Third, the present study employed subjective information on self-reported alcohol consumption and hours of sleep per night that may have induced bias. Further studies should include objective data, e.g., on BMI, sleep disorders (e.g., acute/chronic sleep [90]), hours of sleep, mileage, yearly income, smoking, and disease diagnosed (e.g., diabetes mellitus, hypertension, among others [13]). (In fact, this kind of data was requested but not provided by the BRT operator.) Scales such as Epworth Sleeping Scale, Pittsburgh Sleep Quality [13], or similar should also be included for future research.
- Fourth, the self-reported accident involvement may be inaccurate, i.e., there is a need to distinguish between those crashes where the BRT drivers' actions contributed to them and those due to the violations of other road users (e.g., motor cars, taxis, buses, cyclists, motorbikes, pedestrians) that invade BRT lanes. Hence, in future research, this distinction should be clearly stated and considered when conducting the analysis.

Despite these limitations, the study offers important contributions to the growing body of research on the ADB, fatigue, and poor quality of sleep of BRT drivers in urban environments; as highlighted in the present study, empirical data on these issues, among others, are scarce. By integrating these findings into the key-decision system, it is hoped that these may contribute to a better understanding of the factors leading to accident occurrence so that decision-makers would implement measures aimed at preventing such undesirable events and thereby contributing to sustainable traffic safety and urban mobility.

5. Conclusions

A great deal of effort has been made to investigate and develop approaches to address driver behavior, fatigue, and sleepiness for different road users worldwide. However, very little research has been conducted to explore these issues in the context of BRT drivers in a low-income countries such as Mexico. The study filled this gap by addressing ADB, fatigue, and poor sleep among BRT drivers of one of the BRT line operators in Mexico City. The sample size employed was $n = 152$ professional drivers and the sampling was for convenience; hence, the results apply only to the BRT operator that participated in the study. Furthermore, the results should be taken with caution given the limitations of the study.

Overall, the main conclusion of the study is that ADB, sleepiness, and fatigue are real and existent among BRT drivers and should be a cause of concern for the case of the BRT organization that took part in the study. Furthermore, the study confirmed that (a) the created 34-item BRT-ABDQ helped to identified two ADBs (violations and errors); (b) violation factor but not errors contributed to accident involvement; (c) ADB, subjective fatigue, poor sleep and age (30–39) were predictors of accident involvement; and (d) a significant linear trend has been revealed indicating that as the hours of sleep decreased, the experience of fatigue increased proportionally.

More generally, it is believed that around 190 cities worldwide have implemented BRT systems carrying over 32 million passengers a day. However, BRT systems are the least studied when compared to other mass transit systems. More research is needed on BRT drivers' fatigue, quality of sleep, work shifts, and related issues.

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Institutional Review Board Statement: Ethical review and approval were waived for this study due to the use of fully anonymized and aggregated data collected through voluntary participation. The

study involved no collection of personally identifiable information, and verbally informed consent was obtained from all participants prior to completing the questionnaire. The study was conducted in accordance with the Regulations of the General Health Law on Health Research (Article 3, Section I, Article 4, Article 6, Title II, Chapter I, Article 17, Section II) and its update published in the Official Gazette of the Federation (Ministry of the Interior, 2014) [91]. We also considered the Mexican Official Standard NOM-012-SSA3-2012 [92] (Section 5, Items 5.3 to 5.13 and 5.15) and determined that the research posed minimal risk to the participants, to whom we provided sufficient information to allow them to voluntarily decide on their participation.

Informed Consent Statement: Verbal consent was obtained rather than written because the study posed no physical or psychological risk to participants, data were collected anonymously. Participants were fully informed about the purpose of the study, their right to decline or withdraw at any time, and how their data would be used and protected.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed at the corresponding author.

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Conflicts of Interest: The author declares no conflicts of interest.

Appendix A

Table A1. Examples of professional BRT drivers' job characteristics.

Characteristics	Description
Training	Drivers receive professional training and certifications for operating BRT buses, training for providing quality service to passengers, among others.
Articulated buses	Driving four types of bus: articulated, 18 to 23 m long (160 passengers); bi-articulated, 24 to 27 m long (240–270 passengers); double-decker (12–13 m long and 90–130 passengers); and standard buses, 12 m long with a capacity of 60–80 passengers.
Driving dedicated lanes	Driving in exclusive lanes demands a high level of discipline to adhere to tight schedules and manage internal traffic within the corridor. This requires drivers to maintain a high level of concentration to avoid collisions with vehicles that “turn-left” or invade the BRT lane, while maintaining a constant speed of 30–50 km/h.
Stop and docking precision	Drivers must align articulated or bi-articulated buses with high precision at stations to allow the bus doors to match those of the station.
Safe driving	Due to the size of the buses and the high volume of passengers, drivers concentrate on passengers' safety and ensuring continuous operation.
Work shift	Drivers face different working hours (morning shift from 4:30 p.m. to 1:00 a.m.; afternoon from 12:00 p.m. to 7:00 p.m.; night from 6:00 p.m. to 1:00 a.m.).
Use of technology	They are trained to handle new technologies, such as electric buses, and rely on automated payment systems, among others.

Table A2. Examples of challenges/difficulties of BRT drivers.

Challenges/Difficulties	Description
Invasion exclusive lane	Drivers face the challenge of performing emergency maneuvers and sudden braking and often result in injuries to passengers and accidents due to other road users (e.g., cyclists, motorcyclists, motorists, and pedestrians) invading the lane daily.
Traffic and critical maneuvers	Drivers require high skills to align capacity buses with precision at stations to allow these buses' doors to match those of the stations; moreover, they also must maneuver in very dense pedestrian areas, narrow streets, among others.
Limited visibility	Due to the size of the buses, it creates “blind spots” which hinder the visibility of pedestrians, cyclists and small vehicles, thus complicating operations at busy intersections.

Occupational Health	They face high levels of stress due to tight schedules, long working hours, and the responsibility for the safety of passengers. Prolonged exposure to vibrations, engine noise, among others.
Conflicts and road coexistent	Drivers not only have to deal with lane invaders, but they also must coexist with other modes of transport that try to overtake or do not follow traffic regulations.
External factors	Weather conditions and unexpected obstacles on the road, such as slippery roads when it rains, ground subsidence in certain sections of the lane, unsynchronized traffic lights, and reckless pedestrian behavior, among others.
Time pressure and passenger behavior	They deal with time pressure, which sometimes creates tension with passengers regarding door closing or boarding/descending, in addition to dealing with cases of passengers' misconducts.
Unexpected events	Earthquakes, pedestrians or cyclists who refuse to leave the confined lane, among others.

Appendix B

Table A3. Original DBQ items and items selected for the BRT-ADBQ.

Original Items	Final Items Considered in the Analysis (Modified/Created if Needed)
1. "How often do you disregard speed limit to catch up or avoid being late to bus station from bus depot?" ^a (V)	Q1. "How often do you disregard speed limit to catch up or avoid being late to bus station from bus depot?"
2. "Check your speedometer and discover that you are unknowingly travelling faster than the legal limit." ^b (V)	Q2. "Check your speedometer and discover that you are unknowingly travelling faster than the legal limit."
3. "Crossing a junction knowing that the traffic lights have already turned against you." ^b (V)	Q3. "Crossing a junction knowing that the traffic lights have already turned against you."
4. "Disregard red lights when driving late at night along empty roads." ^b (V)	Q4. "Pay attention to red lights when driving late at night along empty roads."
5. "Driving with one hand on the steering wheel." ^c (E)	Q5. "Driving with one hand on the steering wheel."
6. "Use the cellular (mobile) phone while driving." ^d (E)	Q6. "Use the cellular (mobile) phone while driving."
7. "Take more passengers than allowed." ^d (V)	Q7. "Take more passengers than allowed."
8. "Missing stop due to no passenger present in station." ^d (V)	Q8. "Missing stops due to no passengers present in station."
9. "Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa." ^b (E)	Q9. "Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa."
10. "Misjudge your gap while parking and nearly (or actually) hit adjoining vehicle." ^b (E)	Q10. "Misjudge your gap while parking and nearly (or actually) hit adjoining vehicle."
11. "While driving on the road, you fall asleep and wake up to realize that you have no clear recollection of the road along which you have just travelled." ^a (E)	Q11. "While driving on the road, you fall asleep and wake up to realize that you have no clear recollection of the road along which you have just travelled."
12. "Lost in thought, you forget that your lights are on full beam until flashed by other drivers." ^b (E)	Q12. "Lost in thought, you forget that your lights are on full beam until flashed by other drivers."
13. "Try to drive away despite the back doors being open." ^d (E)	Q13. "Try to drive away despite the door is open."
14. "I fail to check my rear-view mirror before pulling out from a bus stop." ^d (E)	Q14. "I check my rear-view mirror before pulling out from a bus stop."
15. "Braking suddenly at bus stop." ^c (E)	Q15. "Braking suddenly at bus stop."
16. "Lost in thought or distracted, you fail to notice someone waiting at a zebra crossing, or a pelican crossing light that has just turned red." ^b (V)	Q16. "Lost in thought or distracted, you fail to notice someone waiting at a zebra crossing, or a pelican crossing light that has just turned red."
17. "While closing the vehicle doors, how often the passengers or objects get struck in between the vehicle door." ^a (E)	Q17. "While closing the vehicle doors, how often the passengers or objects get struck in between the vehicle door."
18. "Try to keep minimum safe distance from the vehicle in front." ^a (P)	Q18. "Try to keep minimum safe distance from the vehicle in front."
19. "Try not to honk unnecessarily, so as to avoid affecting others." ^a (P)	Q19. Try using your horn to alert cyclists/motorcyclists/pedestrians when they invade your lane.
20. "Angered by another driver's behavior, you give chase with the intention of giving him/her a piece of your mind." ^b (V)	Q20. "Angered by another driver's behavior, you give chase with the intention of giving him/her a piece of your mind."

21. "Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late." ^b (E)	Q21. "Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late."
22. "To leave much clear gap between vehicle and station." ^a (E)	Q22. "To leave much clear gap between vehicle and station."
23. "Not able to precisely stop the bus at bus stop with the bus door exactly parallel to the stop door at station." ^a (E)	Q23. "Not able to precisely stop the bus at bus stop with the bus door exactly parallel to the stop door at station."
24. "Avoid braking too hard considering passenger discomfort." ^a (P)	Q24. "Avoid braking too hard considering passenger discomfort."
25. "Drive especially close or flash the car in front as a signal for that driver to go faster or get out of your way." ^b (V)	Q25. Drive especially close or flash at vehicles (cars/motorcycle/bicycle users, pedestrians) that invade your lane to go faster or get out of your way.
26. "Fail to notice pedestrians crossing when turning into a side-street from a main road." ^b (E)	Q26. "Fail to notice pedestrians crossing when turning into a side-street from a main road."
27. "Get into the wrong lane at a roundabout or approaching a road junction." ^d (E)	Q27. "Get into the wrong lane at a roundabout or approaching a road junction."
28. "Invade a junction or intersection, causing a bottleneck for incoming vehicles." ^c (V)	Q28. Invade the lanes assigned to pedestrians and cyclists.
29. Same as above.	Q29. "Invade a junction or intersection, causing a bottleneck for incoming vehicles."
30. "Miss "Yield" or "Stop" signs; narrowly avoiding a collision." ^d (V)	Q30. "Miss "Yield" or "Stop" signs; narrowly avoiding a collision."
31. "Turn or change lanes suddenly." ^c (E)	Q31. "Suddenly turn or change lanes."
32. "Driving more than 30 km/h in garages or portals." ^c (V)	Q32. "Driving at over 30 km/h on the main road."
33. "Driving even though you have consumed alcohol." ^c (V)	Q33. "Driving even though you have consumed alcohol."
34. "Driving without a seat belt on." ^e (V)	Q34. "Driving without a seat belt on."

V = violations; E= errors, P = positive. ^a [26], ^b [24], ^c [44], ^d [31], ^e [13].

Appendix C

Appendix C.1. Trend Contrast

A polynomial contrast was conducted to investigate the trend of the data; the selected degree of polynomial was lineal and quadratic (i.e., given that the data have only three groups). To detect a meaningful trend, the code grouping of the hours of sleep variable was in descending order, i.e., 1 = 6–8 h, 2 = 4–6 h, and 3 ≤ 4 h of sleep.

Table A4. Descriptives.

Group	N	Mean	SD	Std. Error	95% CI for the Mean [Lower–Upper]
1 (6–8 h)	31	2.8018	1.31277	0.23578	[2.3203–3.2834]
2 (4–6 h)	94	3.5502	1.33897	0.13810	[3.2759–3.8244]
3 (<4 h)	27	3.6296	1.35715	0.26118	[3.0928–4.1665]
Total	152	3.4117	1.36400	0.11064	[3.1931–3.6302]

Table A5. Test of homogeneity of variance.

Group	Levene Test	df1	df2	df3
Subjective fatigue	0.024	2	149	0.977

Table A6. ANOVA.

		Sum of Squares	df	Mean Square	F	Sig.
Between groups	Combined	2.8018	14.614	2	7.307	4.09
	Linear term	Contrast	10.614	1	10.614	5.938
		Deviations	3.999	1	3.999	2.238
						0.137

	Quadratic term	Contrast	3.999	1	3.999	2.238	0.137
Within groups			266.322	149	1.787		
Total			280.936	151			

Appendix C.2. Planned Comparison

Hypothesis (one-tailed): Few hours of sleep (<4 h) increase the subjective experience of fatigue compared to having more hours of sleep (6–8 h.)

Table A7. Contrast coefficients.

Contrast	Group 1 (6–8)	Group 2 (4–6)	Group 3 (<4)
1	−1	0	1

Table A8. Contrast test.

	Contrast	Value of Contrast	Std. Error	Mean Square	<i>t</i>	Sig. (Two-Tailed)
Fatigue Assume equal variances	1	0.8278	0.35193	2.352	149	0.020

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