

Measuring Fatigue and its Associations with Job Stress, Health and Traffic Accidents in Professional Drivers: The Case of BRT Operators

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Abstract

Driving of motor vehicles constitutes, undoubtedly, a very complex and demanding task. Moreover, if we regard to the field of professional driving, we will find that driving labor implies different adverse and threatening working conditions that potentially affect not only the driving performance, but also the health and welfare of drivers, passengers and other road users. Some of these adverse operational conditions are long periods of driving, overstimulation, exposition to different stressors and irregular break shifts, that may explain a major predisposition to reporting mental and psychological symptoms of fatigue, stress and a substantial decreasing of driving performance. Briefly, there is a combination of conditions that increases the risk of suffering different health complains, negative occupational outcomes and, even, traffic crashes. The main objective of this study was to describe the associations between fatigue indicators, job stress, health factors and traffic crashes among BRT drivers. Further, this research has also the complimentary purpose of presenting psychometric properties of two scales used to measure general fatigue, and work-related fatigue -or need for recovery- among professional drivers. For this cross-sectional study, it was used a sample of 524 Colombian BRT operators, who answered a questionnaire composed by three sections: in the first, it was scoped a set of demographic and individual indicators; in the second section, fatigue was measured using the Subjective Fatigue Scale of Checklist of Individual Strength (CIS) and the Need for Recovery Scale (NFR). Finally, in the third section work stress was measured using JCQ and ERI questionnaires. Apart of finding good psychometric properties of the two scales used to measure fatigue, significant correlations between both fatigue measures and work stress, daily hours driving and driver's age were found. Also, it was established a set of associations between the level of fatigue of BRT divers with some health complains (i.e. diabetes, high cholesterol and ergonomic disorders), both measures of job stress, and self-perceived risky driving. As conclusion, fatigue constitutes a relevant factor to be taken into account to design interventions aimed to improving working conditions and to promote operators' welfare, regarding its relationship to adverse psychosocial factors at work, such as work stress (under Demand-Control and Effort-Reward Imbalance models) that, according to the evidence, are potential predictors of risky behaviors, traffic accidents and negative health outcomes among professional drivers.

Keywords: *Fatigue; Job Stress; Traffic Accidents; Professional Drivers; BRT Drivers; Working Conditions*

Abbreviations

BRT: Bus Rapid Transit; NFR: Need for Recovery; CIS: Checklist for Individual Strength

Introduction

Driving is a very demanding task, taking into account that it involves the simultaneous execution of multiple processes of physical and

cognitive order during relatively long periods of time and with inflexible margins of error [1,2]. It is a demonstrated fact that, in driving, the prolonged and strict driving periods [3], monotony [4,5], ergonomic issues [6,7] and repeated demands for adjustment [8] are factors that constantly accompanies this work. According to the evidence, driver fatigue represents one of the leading causes of death in the transportation industry, regarding its close relationship to the impairing of the driving performance [9,10]. In fact, recent studies affirm that driver fatigue could be considered as a major contributor to a percentage up to 30% of all reported traffic crashes of professional drivers [11,12].

Bus Rapid Transit (BRT) is a worldwide growing modality for public service transport, consisting in bigger buses that may carry more passengers, increasing the efficiency of massive personnel transportation, but implying, at the same time, more psychological and physical demands to its operators [13,14]. Empirical research collected over the past decades shows that, compared to different occupational groups, professional drivers, in general, tend to report a greater risk of suffering different types of diseases (i.e. mental and physical health problems), and to be involved in occupational accidents [15,16]. However, mental health indicators and its relationship to drivers' performance and welfare have been scoped with less frequency than other health issues [17].

Regarding the high-demanding characteristics of professional driver's work-in this case, public transport operators-, the frequent impossibility of take short breaks and recovery periods amid task explains further accumulation of fatigue, which can be reflected in a decreased ability to maintain vigilant mood and attention focused on the task during the entire period of driving [1,18,19]. In fact, one of the conditions that characterize the occupation of public transport drivers is the difficult to plan the duration, intensity and objective conditions in which the driving task occurs [8,20]. This phenomenon predisposes the driver to perform their work along irregular shifts and unpredictable situations, both by road conditions (e.g. weather, traffic flow, lighting), as well as by the often problematic behaviors of other road users, including passengers in the case of drivers of public service vehicles [1,21]. This irregularity can affect the rest/break periods that normally are reduced or altered to compensate time losses, derived from difficult road conditions and delays caused by service failures [1,22,23].

In the field of occupational health, work-related diseases usually develop over an extended period of time. There are slow and generally cumulative process that precede the expression of their symptoms, and often become complicated by non-occupational factors, reason for that use to be often underestimated [24,25]. In the mid and long term, professional drivers may result very affected due to constant exposure to (e.g.) visual overstimulation, contamination sources and stressors. For instance, recent studies have shown that long-term exposure to whole-body vibration and rough road surfaces, combined with a lack of resting and body exercising, can result in different problems [26], such as a higher perception of mental and physical fatigue [27], driving stress [28] and the collateral appearance of musculoskeletal issues [29]. Since professional drivers have, in most cases, to meet very strict timetables and inflexible schedules [14,30], this work under constant pressure explains that the physical and psychological strain use to be higher when comparing professional drivers with other groups of workers. This results, in fact, contradictory to the idea of "safe driving", considering that driving under adverse conditions, such as fatigue and stress, increases significantly the probability of occurrence of road accidents [31,32].

Impact of fatigue in driving performance

As it was briefly mentioned along the introduction, many scientific studies have shown that inherent factors to the professional drivers' job, such as long hours of continuous driving [23,33] and monotonous driving –specially at night and in early hours' shifts- [9] explain a substantial decrease in terms of driving performance and safe behaviors at the wheel [34].

The objective symptomatology of fatigue use to be mainly experienced during or after a day of work [1,35]. In this sense, resting time represents a critical variable in the optimal recovery from the realized occupational efforts [36]. However, this critical condition to guarantee the recovery is usually not fulfilled, due to irregular shifts in which drivers normally work, that interrupt the break between two strict working shifts and, even, the duration and quality of sleep periods [1,33,37].

Specifically, among city bus drivers, there are various working modalities according to driving hours, some of them more critical than others for the health of this occupational group [1,23,38]. In a previous study, Cendales Gómez and Useche [14] found that rates of self-reported fatigue were higher on drivers of public service performing two daily shifts (split schedule) than those performed during only one shift per day, although this shift lasts twice as long.

According to the evidence, the main cause of fatigue of drivers shows to be sleepiness derived from sleep loss, staying awake for excessive periods, and the fact of driving during the circadian low [39]. According to the studies performed by Sluiter [1] and other research experiences [30,40], repeated insufficient recovery from work-related fatigue, could be explained as the take-off of a vicious circle; in this sense, the performed extra effort “has to be exerted at the beginning of every new working period to rebalance the sub-optimal psychophysiological state, and to prevent performance breakdown” [1].

Given that rest is the mechanism par excellence by which recovery is performed, in situations of repeated exposure to stressors, prolonged activation and insufficient rest, it is common to find a break in the homeostatic balance, following a cumulative adjustment process, resulting in negative psychological and physiological reactions that may become irreversible in the health of drivers [1,11,20,39]. Some of these effects, according to their complexity, can range from a simple prolonged feeling of fatigue to chronic sleep problems and the development of symptoms related to burnout, all of them potentially impairing the driving performance [41,42].

Previous studies realized using the Need for Recovery Scale (NFR), designed to measure the job fatigue, have concluded that higher scores are associated with higher rates of occupational accidents, health problems (both physical and mental hazards/illnesses) and work absenteeism [43].

Professional drivers and adverse work conditions

As previously mentioned, the occupational group of professional drivers is, with no doubt, one of the most affected by different adverse working conditions, such as fatigue, stress, physical and mental illnesses [15,44]. It is important to remark that, due to the expression of some diseases occurs essentially in the mid and the long term, often these illnesses are not related directly to the occupational labor, but, in fact, are derived from the repeated exposure to unfavorable and unhealthy working conditions that affect most of professional drivers. Furthermore, many of the studies relating fatigue, stress and health have been conducted with bus drivers. This phenomenon could be partially explained by the fact that professional drivers are one of the occupational groups with a higher risk in this regard [45,46]. Some of these mentioned studies use to conclude that professional drivers tend to report feelings of fatigue, strain and physical/mental overload [1,47]. Furthermore, Belkic, *et al.* [45] argue that contradictory orders and adverse circumstances which normally are part of the driving shifts (generally under time pressure) can facilitate the development and maintenance of conditions of occupational stress and fatigue.

Relationship between fatigue, stress and health

Occupational risk factors are, consistent to the existing evidence, related to adverse consequences of different order not only at work, but in different life spheres of workers [1,48]. Although the mechanism by which the combination of stress and fatigue exert a progressive deterioration of health in the medium and long term has not been fully clarified by the studies, the causal relationship between these factors and work-related illnesses of professional drivers is well-documented [47,49]. According to Sluiter, Van der Beek and Frings-Dresen [50], the cumulated fatigue from repeated insufficient recovery is related to health problems in various ways.

Several research experiences have associated physical and psychological working conditions of drivers with physical and mental diseases. Within the typology of “physical illness” highlights musculoskeletal [6,29] cardiovascular [47,51], nutritional, metabolic and even endocrine disorders [52,53], substantially explained not only by fatigue, but presenting high morbidity with other potential diseases affecting professional drivers.

According to the evidence, in the case of bus drivers there are typical conditions from the intense driving that may affect both the physical health of drivers, as the reported rates of fatigue and informed discomfort, such as vibration, noise, pollution, excessive environ-

mental stimulation, and driving under adverse weather conditions [25,45,48]. A preceding study realized in the United States found that 80.5% of drivers were experiencing back or neck pains, with 10% reporting severe pains [54]. Specifically, in the case of bus drivers, Szeto and Lam [29] have found that, in Hong Kong, from 35% to 60% of male drivers have reported neck and back pains as associated to long hours of driving.

Regarding connections between fatigue and stress, some studies have accumulated evidence of this relationship among professional drivers. As in the paradigm of transactional theory of stress [55], in the case of fatigue it has been given a significant value to the subjective experience and its appraisal, in terms of their potential impact on the driving task. Similarly (although not identically), in the case of stress coping, the identification and understanding of the causes, the intermediate process and consequences of fatigue on driving, represents an interesting element to promote health in drivers.

According to De Lange, *et al.* [35], who have studied job stress of professional drivers under the Demand-Control approach, in recent studies it has been determined that the task of driving under high work demands and low job control contributes to develop risk factors concerning to mental and physical health. Job demands (which generally tend to be excessive) tend to manifest themselves in the medium and long-term in the health of workers [43]. According to Bhatt and Sheema [26], professional drivers must respond to various demands under circumstances of lack of control. Although there are not too many in-depth studies documenting the relationship between job stress-sleep-fatigue, as most of them are cross-sectional [22], some recent prospective investigations have determined that the problems in the rest and recuperation have a statistical effect of explanatory type on occupational diseases and work disability [18].

Some subjective symptoms related to states derived from driver fatigue are mentioned in Desmond and Matthews [55] and other empirical studies [10,38,56]. Regardless of the subjective assessments of drivers, there are (usually) reported higher prevalence physical discomfort, animistic, motivational and cognitive fluctuations and changes in the effectiveness of driving [43,55]. Although not all studies that have sought to determine the relationship between fatigue and driving performance are consistent among themselves, it seems, on the other hand, that subjective symptoms of fatigue (e.g. tiredness, lack of energy and general discomfort) are factors that partially explain a lower performance behind the wheel, expressed in risky behaviors (errors and violations) and traffic accident' records [14].

Objective

The aim of this research was to describe the associations between fatigue indicators, job stress, health indicators and traffic crashes among BRT drivers.

By examining the association between fatigue, work stress and work characteristics, mental health and accident involvement of BRT operators seeks to contribute to increase the knowledge related to the psychosocial risk factors that these drivers are subject to, and its relation to negative outputs in terms of health, welfare and safety outputs. It is important to remark that driver fatigue has shown to be a key risk factor for traffic accidents in several high-income countries, but it is still receiving a non-significant attention in low and middle-income countries [56].

Additionally, this work aimed to present the psychometric properties of two scales suggested to use to measuring different aspects of fatigue among professional drivers: The Checklist for Individual Strength (CIS) [57] and the Need for Recovery Scale [58].

Materials and Methods

Sample

For this cross-sectional study, it was used a sample of $n = 524$ Colombian BRT operators, who answered a questionnaire after having agreed to participate in the study. The average age of the participants was $X = 40.48$ ($SD = 7.7$) and all were male. The average time as drivers was $X = 17.59$ years ($SD = 7.31$) and the operators had been working for the company for at least a year. This study aimed to guarantee that the self-reporting information regarding the working conditions referred to current characteristics and that if any relationship

with accident rates and health were established, there would be greater certainty that the working conditions in question were the most recent.

Instruments

The questionnaire was administrated in Spanish language, and consisted of various sections:

In the first section, demographic variables (age, driving experience), risky driving perception and road accidents suffered along the last three years) were collected.

In the second section, the following scales were used to measure fatigue: First, the “subjective fatigue” subscale of the Checklist for Individual Strength (CIS) [57], which consists of 8 items in which the respondent has to indicate on a 7-point scale to what extent each statement applies to the participant. The Checklist Individual Strength (CIS) measures perceived subjective fatigue and related behavioral aspects [59]. The Cronbach’s alpha coefficient of the scale was $\alpha = 0.86$. Other studies using the same scale (in different languages) have reported reliability coefficients of $\alpha = 0.78$ and $\alpha = 0.96$ [57,60].

Secondly, the Need for Recovery after Work Scale, NFR [58] is an 11-item dichotomous scale used to measure mental and physical work-related fatigue symptoms, in this with a reliability oscillating between $\alpha = 0.68$ and $\alpha = 0.80$ [58,61]. The NFR qualification is carried out according to the number of positive responses (the presence of symptoms) of work-related fatigue from a total of 11 possible items (100%), but can be transformed to a continuous score.

Complimentarily, in the third section, with the aim of assessing work stress, two self-report scales were used, which assess the psychosocial factors proposed by the two stress aforementioned models:

For the Demand-Control model, it was used the Job Content Questionnaire (JCQ) [62] in its Spanish version validated for Colombian working population [63]. This 27-item scale, used to assess psychosocial factors at work that could potentially lead to job strain, is made up by six subscales: skill discretion ($\alpha = 0.5$); decision authority ($\alpha = 0.61$); psychological demands ($\alpha = 0.67$); supervisor and manager support (4 items, $\alpha = 0.78$); peer or colleague support ($\alpha = 0.72$); and job insecurity ($\alpha = 0.61$). Job control was calculated as the sum of skill discretion and decision authority ($\alpha = 0.65$).

For the Effort-Reward Imbalance model, it was used the ERI Questionnaire [64,65], in its short version (10-item). This scale was used to assess psychosocial risk factors at work for stress according to the factors proposed in the effort-reward imbalance model: extrinsic effort (3-item, $\alpha = 0.73$; $\alpha = 0.74$ original) and reward (7-item, $\alpha = 0.77$; $\alpha = 0.79$ original). The 23-item version of the ERI questionnaire had previously been validated in Colombia by Gómez (2010). From this validation, 10 items were validated corresponding to the short version by Siegrist, Wege, Pühlhofer and Wahrendorf [65].

Procedure and Ethics

BRT operator companies were invited to participate in the study. All BRT operators were asked to voluntarily complete the questionnaires during a one-hour period provided by the respective companies (participation rate $\approx 98\%$). The study was previously approved by the Universidad de Los Andes Ethics Committee, and the participants were informed of their rights and the protection of their personal information in an informed consent form. In this sense, the survey was conducted guaranteeing the anonymity of the participants, and emphasizing on the fact that the data would only be used for research purposes. It was used an informed consent statement, signed by both parties before the participants answered the questionnaire.

Statistical Analysis

Descriptive statistics and basic psychometrics were performed to appraise the results obtained regarding the applied fatigue scales. Pearson correlations between the study variables were obtained to characterize the association between the main stress-related indicators for BRT operators (job strain, effort/reward imbalance) and fatigue measures. Further, Chi-Square test were performed to study

potential contingencies between categorical variables (e.g. fatigue levels and health and accident records). All statistical analyses were performed using ©IBM SPSS (Statistical Package for Social Sciences), version 23.0.

Results

First of all, and regarding the objective of determining the psychometric properties and factor adjustment of the two employed scales to measuring fatigue among professional drivers, descriptive data and basic psychometrics of CIS’s Subjective Fatigue Scale and Need for Recovery Scale are presented below:

CIS’s Subjective Fatigue Scale

Globally, the Subjective Fatigue Scale of CIS present a good 1-factor structure, taking into account the component weights of the entire set of items of this brief questionnaire. Having realized the conversion of negative items, the higher means correspond to items 1 (I feel tired; X = 2.46), 2 (Physically I feel exhausted; X = 2.29) and 6 (Physically I feel I am in bad form; X = 2.24), as shown in Table 1.

Item	Mean		SD	Component weight
	Statistic	Std. Error		
1. I feel tired	2.46	0.07	1.51	0.813
2. Physically I feel exhausted	2.29	0.07	1.47	0.843
3. I feel fit ⁽⁻⁾	2.07	0.07	1.45	0.707
4. I feel powerless	1.93	0.06	1.30	0.741
5. I am rested ⁽⁻⁾	2.78	0.08	1.72	0.605
6. Physically I feel I am in bad form	2.24	0.07	1.58	0.720
7. I tire easily	1.99	0.06	1.33	0.699
8. Physically I feel I am in an excellent condition ⁽⁻⁾	2.42	0.08	1.69	0.655

Table 1: Descriptive data and factorial weights of CIS’s subjective fatigue scale.

Confirmatory factor analysis (CIS)

For the conduction of the confirmatory factorial analysis, and taking into account that once conducting the Kolmogorov-Smirnov test (to determine whether Fatigue measured by CIS was -or not- normally distributed) the result showed that the sample was not normally distributed in terms of this variable (K-S = 0.122; p < 0.001). For this factorial analysis, it was used as estimation method the maximum likelihood, with broad error standards and Chi-square correction for its mean and asymptotic variances.

With the obtained factor solution, resulting from the Principal Component analysis, it was reached the 52.79% of total explained variance. Factor loading coefficients range from 0.605 (minimum) and 0.843 (maximum), with items 1 and 2 the items those best fit the only factorial component obtained, as shown in Table 1.

Internal Consistency

Regarding the internal consistency/reliability coefficient of the CIS in Colombian BRT drivers, it was found a Cronbach’s alpha of $\alpha = 0.866$ for the full-scale, whereas when performing the reliability analysis using the “two halves” method, it was found a Cronbach’s alpha coefficient of $\alpha = 0.841$ for part 1 (items 1, 2, 3, 4, 5 and 6), and a Cronbach’s alpha coefficient of $\alpha = 0.774$ for part 2 (items 7, 8, 9, 10 and 11), with a correlation within forms of $r = 0.715$. Throughout Hotelling’s T-Squared test, it was found a coefficient of $F(7,460) = 29.22$; $p < 0.001$.

Need for Recovery Scale

Regarding NFR, it has been observed an optimal adjustment to 1-only factor. According to the frequency analysis, the most prevalent

symptoms of fatigue derived from work labor are the items 4 (After the evening meal, I generally feel in good shape; 60.7% of respondents), 3 (Because of my job, at the end of the working day I feel rather exhausted; 46.4% of respondents) and 2 (By the end of the working day, I feel really worn out; 43.4% of respondents).

Confirmatory factor analysis (NFR)

For the conduction of the confirmatory factorial analysis, and taking into account that once conducting the Kolmogorov-Smirnov test (to determine whether Need for Recovery was -or not- normally distributed) the result showed that the sample was not normally distributed in terms of this variable (K-S = 0.192; $p < 0.001$). For this factorial analysis, it was used as estimation method the maximum likelihood, with broad error standards and Chi-square correction for its mean and asymptotic variances.

With the obtained factor solution, resulting from the Principal Component analysis, it was reached the 37.28% of total explained variance. Factor loading coefficients range from -0.245 (minimum) and 0.720 (maximum), being items 3 and 10 those who best fit the only factorial component obtained, as shown in the Table 2.

Item	Frequency		Mean		SD	Component weight
	Yes	No	Statistic	Std. Error		
1. I find it difficult to relax at the end of a working day	16.4%	83.6%	0.16	0.02	0.37	0.499
2. By the end of the working day. I feel really worn out	43.6%	56.4%	0.44	0.02	0.50	0.700
3. Because of my job, at the end of the working day I feel rather exhausted	46.4%	53.6%	0.46	0.02	0.50	0.720
4. After the evening meal, I generally feel in good shape	60.7%	39.3%	0.61	0.02	0.49	-0.245
5. In general, I only start to feel relaxed on the second non-working day	25.0%	75.0%	0.25	0.02	0.43	0.566
6. I find it difficult to concentrate in my free time after work	8.40%	91.6%	0.08	0.01	0.28	0.560
7. I cannot really show any interest in other people when I have just come home myself.	13.2%	86.8%	0.13	0.02	0.34	0.628
8. Generally, I need more than an hour before I feel completely recuperated after work	37.7%	62.3%	0.38	0.02	0.49	0.664
9. When I get home from work, I need to be left in peace for a while	18.6%	81.4%	0.19	0.02	0.39	0.591
10. Often, after a day’s work I feel so tired that I cannot get involved in other activities	25.9%	25.9%	0.26	0.02	0.44	0.702
11. A feeling of tiredness prevents me from doing my work as well as I normally would during the last part of the working day	20.2%	79.8%	0.20	0.02	0.40	0.689

Table 2: Descriptive information and factorial weights of NFR.

Internal consistency

Regarding the internal consistency/reliability coefficient of the NFR in Colombian BRT drivers, it was found a Cronbach’s alpha of $\alpha = 0.776$ for the full-scale, whereas when performing the reliability analysis using the methodology of “two halves”, it was found a Cronbach’s alpha coefficient of $\alpha = 0.511$ for part 1 (items 1, 2 and 3), and a Cronbach’s alpha coefficient of $\alpha = 0.741$ for part 2 (items 3, 4, and 5), with a correlation within forms of $r = 0.657$. Throughout Hotelling’s T-Squared test, it was found a coefficient of $F(10,482) = 80.05$; $p < 0.001$.

Correlations between fatigue, individual factors and work stress

Correlational analysis showed significant associations between the two used fatigue measures (general fatigue and fatigue derived from work) and several variables related to psychosocial factors at work of BRT operators, as shown in Table 3.

		Mean	SD	1	2	3	4	5	6	7	8
Demographic data and work characteristics											
1	Age	40.63	7.69	1	.733**	-0.048	-.125**	-.113*	-0.028	-0.028	.155**
2	Experience	17.62	7.32		1	-0.059	-0.094*	-0.127**	-0.004	-0.032	.060
3	Working Hours	8.29	1.12			1	.238**	.136**	.339**	.223**	.059
Fatigue											
4	General Fatigue	18.08	8.64				1	.605**	.493**	.463**	0.016
5	NFR	3.14	2.59					1	.476**	.472**	0.063
Work stress											
6	ERI	.972	.459						1	.619**	.116*
7	Job Strain (JCQ)	.964	.324							1	0.041
Road Safety Outputs											
8	Traffic accidents (3 years)	.630	.954								1

Table 3: Descriptive data and Pearson correlations of the entire set of study variables.

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Regarding work stress measures, there are positive correlations between general fatigue and fatigue derived from work and both stress indicators (Job Strain and Effort-Reward Imbalance). In this sense, operators who report higher levels of fatigue use to present, simultaneously, upper scores in terms of job stress, and vice versa, as shown in Table 3.

General and work-related fatigue also correlated positively with the number of daily working hours (i.e. longer driving shifts, more reported fatigue in both measures). Regarding age and experience of professional drivers, negative correlations between both fatigue measures and age/driving experience were observed.

Comparisons between drivers with different fatigue levels

Associations between fatigue level and physical illness

Regarding the studied relationship between fatigue of drivers and their self-reported health indicators, it was determined through Chi-Square analyzes that drivers with higher levels of fatigue are more related to report diseases or adverse health circumstances such as diabetes ($X^2 = 5.267$; $p = 0.028$), high cholesterol ($X^2 = 4.415$; $p = 0.026$), and ergonomic illnesses ($X^2 = 11.478$; $p < 0.01$).

Fatigue level and Job Stress

Comparing drivers reporting lower/normal levels of fatigue with those who have higher scores in respect to work stress, significant differences in the Effort-Reward Imbalance between these two groups were found, being the higher scoring for the second, i.e., drivers with higher levels of fatigue ($F(1,418) = 109.44$; $p < 0.01$).

Regarding Job Strain, the work stress indicator from the Demand-Control model, it was also found that this score is significantly upper for BRT drivers with higher levels of fatigue than for those reporting normal or lower scores ($F(1,400) = 98.28$; $p < 0.01$). Both scores, according the fatigue level, are presented in the mean-comparison of the Figure 1.

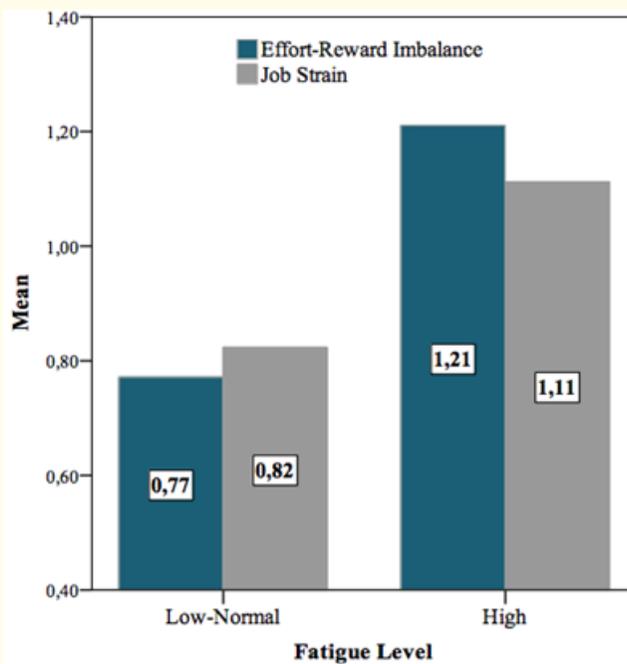


Figure 1: Scores for work stress (ERI and D-C models) according to the reported level of fatigue.

Fatigue level and Risky driving

Finally, it was analyzed the question “¿how much risky do you consider is your driving manner?” (self-perceived risky driving), being this scoring significantly higher for drivers with higher fatigue level (X=1.41; SD = 0.63) than for operators with a normal or lower fatigue level (X = 1.24; SD = 0.54) (F (1,447) = 8.99; p < 0.01). Although number of accidents reported along the last three years is trendy higher for drivers with higher levels of fatigue (X = 0.69; SD = 1.04) than operators reporting normal or lower levels (X = 0.58; SD = 0.86), there are no statistically significant differences among them for the case of this variable.

Discussion

Mental and physical fatigue are, in fact, well-documented risk factors for different occupational groups. In this case, regarding the specific conditions of professional drivers, and the obtained results, it has been found a set of relevant associations between fatigue and negative aspects related to occupational labor. In general, and taking into account the aforementioned, it could be assumed that BRT drivers are not exempt of different hazardous situations and indicators that (taking into account the existing evidence) may affect their health and safety in the short, mid and long term.

In first place, and regarding the relationship between age and subjective perception of fatigue, previously approached through other empirical studies [10,66], it was observed a set of consistent negative associations; in other words, perception of fatigue uses to be trendy higher among drivers with less age and/or driving experience. At the glance of existing literature, it results coherent with the approach of psychological adaptation and adjustment to driving demands. However, although subjective perception of fatigue uses to be (in this case) lower with the advance of age and experience, some studies have documented that these two variables are positively associated to a higher perception of working conditions [8], which may be related to adverse indicators such as work stress and psychological discomfort.

Measures of fatigue are, also, widely associated to reports of job stress among different working groups, specially referring to shift-workers [24], as the case of most of professional drivers [30]. The shift-working population is, in fact, one of the most negatively affected

sectors in terms of measuring of fatigue perception [67], and use to present different signs of health discomfort and illness with the passing of time [68], ranging from transitional factors, such as severe sleepiness [69] and mental overload or underload [70] -that are mainly related to task-related fatigue-, passing by ergonomic problems that impair the normal execution of driving task [7,71,72], to hazardous negative health outputs, such as endocrine [53] and cardiovascular [46,51] diseases.

With no doubt, the case of ergonomic illnesses derived in a substantial part from prolonged driving under fatigue circumstances is one of the most documented aspects of health related to the impairment of driving performance [73,74,75]. In the case of this research, significant associations were found between the reported level of fatigue and the suffering of ergonomic problems (e.g. low back and neck pain and other forms of musculoskeletal disturbances). In this sense, existing evidence have shown the relationship among this type of discomfort and driving accidents, taking into account that driving fitness is relevantly based on the possibility of the accurate operation of the vehicle [6,7,54]. Other relevant associations have also been found between fatigue level and health complains; that is the specific case of diabetes and high cholesterol that are, in the mid and long term, latent risk factors with a high morbidity of severe causes of death, such as myocardial infarction and bloody stools [11,51].

Regarding job stress, in this study it has been found a relevant set of associations between occupational stress indicators and fatigue: first, Pearson correlations associate significantly fatigue to both used stress measures (ERI and Job Strain). Secondly, there are categorical associations (established through Chi-square analyzes) between the fact of perceiving a higher level of fatigue than the mean of BRT drivers, and the fact of presenting job stress, despite which of the two approaches could be taken into account, consistent with other previous empirical evidences [17,51,76].

Later, it has to be discussed obtained association between fatigue level and subjective perception of risky driving of BRT operators. Although other studies have provided evidences regarding differential accident rates or accident potentials among drivers with less and high levels of fatigue [30,41,75], in the case of this research this trend resulted statistically non-significant. However, it has been found (as relevant factor) that drivers presenting a higher level of fatigue use to perceive its driving manner more dangerous than the reported by drivers with lower levels. This fact acquires relevance taking into account that risky behaviors at the wheel keep a certain relationship to accident rates, as shown in different empirical studies [2,28,77].

In regard to the secondary (but not less important) objective of providing psychometrics and adjustment coefficients of used scales for measuring fatigue, we can say that CIS's Subjective Fatigue Scale and Need for Recovery Scale present acceptable and useful properties to be employed in the study of fatigue among professional drivers. In this sense, it has been documented that both CIS and NFR have good reliability, consistence, factor adjustment and internal validity to measure factors related with general and work-based fatigue, and items that may be useful to discriminate between physical and psychological components or symptoms of fatigue [57,58,59]. However, and regarding employable sources of information to study fatigue among drivers, some improvements have been suggested: for instance, task-analysis and monitoring of physiological parameters [80,81] could identify non-declarative components of fatigue that affect drivers' welfare, health and performance, considering that drivers do not use to be completely aware of the complete set of symptoms of fatigue and the importance of its management [10,78,79,82].

Finally, and making reference to the need of developing intervention strategies to reduce the prevalence and adverse impact of fatigue [70] and promote drivers' welfare in the field of public transportation, it has to be taken into account that not all the task components of professional driving are similar/comparable by itself [83,84]; simple features of the task of driving, such as the characteristics of the type of operated vehicles [85], working shifts [30,32], road conditions and subjective health status [31] can explain substantial differences on the appraisal, symptomatology and reported level of incidence of mental and physical fatigue, that, according to the evidence, shows a significant influence on driving performance [86]. For instance, it has been observed in some studies dealing with Colombian samples of drivers that typical stressors and potential sources of fatigue can vary in a broad manner according to (e.g.) the type of contract (temporary or permanent), the level of interaction with passengers and the amount of demands perceived from supervisors and other certain characteristics of the task [14,87]. According to the evidence, it is needed a comprehensive review of the regulations and operational

conditions for commercial motor vehicle drivers [3], conceiving the objective and individual factors that not only may affect drivers, but may potentiate the effectiveness of interventions. Furthermore, and particularly for the case of BRT drivers, despite the positive features and developments that this transportation system presents for operators [13], some specific stressors have to be taken into account, such as contradictory orders, time pressure, environmental overstimulation and lack of control could moderate the appearance and subjective management of stressors or demanding situations at the wheel [88].

Conclusion

Fatigue has been found associated to different adverse health indicators, work stress and performance issues among professional drivers operating BRT vehicles. In this sense, it can be stated that fatigue constitutes a relevant factor to be taken into account to design interventions aimed to improving working conditions and to promote operators' welfare, regarding its relationship to adverse factors at work, such as work stress, risky driving indicators and negative health outcomes.

Additionally, taking into account psychometric properties and obtained measures, CIS's Subjective Fatigue Scale and NFR Scale result in useful questionnaires to study general and work-related fatigue in groups of professional drivers.

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Conflict of Interest

The authors declare no conflicts of interest.

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