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# Accident Risk Factors among Brazilian Shift-Working Truck Drivers

## Running Title: Accident Risk Profiles and Drivers.

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## Abstract

**Objective:** We investigated the relationships among parameters related to accident involvement, sleep patterns and health habits of shift-working Brazilian truck drivers.

**Methods:** In this cross-sectional study, 205 Brazilian truck drivers were invited and accepted to complete our survey based on the validated structured "UNIFESP Sleep Questionnaire". A multiple correspondence analysis was used to assess the clustering of evaluated potential categorical variables with involvement in automobile accidents, aiming to examine associations between these variables.

**Results:** Our results generated two distinct truck drivers' profiles. For the first profile, we observed that drivers who reported involvement in accidents appeared similar to those who reported drug usage, driving more than 14 to 19 hours without rest, excessive sleepiness, falling asleep while driving and sleep complaints. Conversely, the second profile showed that subjects who were not involved in accidents were similar to subjects who reported no sleep complaints or excessive sleepiness, did not falling asleep while driving and did not use drugs. We have also observed that the variable contributing the most to these two profiles was overnight travel, followed by falling asleep while driving and sleep complaints. Our data also demonstrated that exposure to accidents was 4 times higher for drivers who habitually drive during the night. We have also observed a protective effect in terms of accident involvement for drivers who usually work fewer than 12 hours per day.

**Conclusion:** Our results highlighted how adequate sleep habits, as well as, the consequences related to sleep disturbances, are associated with drug consumption and accident involvement by truck drivers.

**Keywords:** Accidents; Fatigue; Overnight travel; Drivers; Drugs; Falling asleep

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## Introduction

Until recently, driving while drowsy has been a major focus of highway safety initiatives aimed primarily at the general public in Brazil. De Mello et al. [1] have demonstrated that, according to the IPEA/Brazilian Federal Government, the average cost of a traffic accident in Brazil is US $5,167 overall; US $1,919 is the cost of accidents without victims, US $52,942 is the cost

 

of accidents resulting in injury, and US $247,647 is the cost of accidents resulting in death. These estimates by the IPEA involved the following aspects: loss of productivity (42.0% of the cost); damage to property (vehicles, city equipment, traffic signs, and property belonging to a third party, amounting to 30.0% of the cost); medical/hospital expenses (rescue, medical treatment and rehabilitation, amounting to 15.9% of the cost); and other costs (legal, traffic jams, social security, removal of the vehicles, other means of transportation, police assistance, traffic officers, and impact on the family, accounting for 11.30% of the cost). These data placed an emphasis on evaluating sleep disorders in "professional" drivers as part of an evaluation of obstructive sleep apnea in Resolution 267/2008 of the Thematic Chamber of Health and Environment in Traffic of National Council of Traffic/ National Department of Traffic (CONTRAN/DENATRAN).

While studies on truck driver fatigue or sleepiness date back to the 1930s, much remains unknown about the extent, causes, and effects of sleepiness-related driving in commercial drivers [2]. Fatigue and sleepiness are considered a high problem, not only because it affects drivers' wellbeing but also because it negatively affects performance and safety [3,4]. Fatigue and sleepiness can occur due to various endogenous and exogenous factors, such as sleep disorders (sleep apnea) [5], poor physical and mental health, advancing age [4], physical workload, nutritional status, alcohol and illicit drug habits or inadequate habits (e.g., poorer sleep quality, high levels of driving exposure; work schedule with long, irregular hours at the wheel during times that conflict with natural circadian rhythms, monotony, permanent night shifts and overtime) [2,4-8]. A comparative study among short haul light and long distance heavy truck drivers identified important contributors to driver fatigue. In general, more than 30% of the drivers reported long driving hours, poor road and weather conditions, loading and unloading and monotonous driving routes. The light drivers also reported some endogenous factors that contribute to their fatigue: inadequate sleep before work, insufficient sleep and insufficient rest breaks [9]. In countries of Europe, Australia, United States and New Zealand sleepiness and fatigue cause 10-30% of accidents with fatalities [10-13]. Furthermore, light (27.1%) and heavy drivers (13.0%) already had collided by fatigue at the wheel [9]. Considering that the direct effects of sleep quality on the increased risks of motor vehicle accidents is a topic already under research, the present study aimed to investigate the relationship between accident involvement, sleep patterns and the health habits of shift-working Brazilian truck drivers. Given this rationale and based on the current literature, we have tested the hypothesis that sleep complaints and their consequences, in association with work conditions and behavior, could result in distinct profiles of drivers who are more likely to be involved in accidents.

# Methods

## Participants

In this cross-sectional study, 205 Brazilian truck drivers were invited and accepted to complete our survey. The study's objective was explained to the participants and, after providing informed consent, the subjects were interviewed by trained personnel at check points, gas stations and rest stations along certain roads across all regions of Brazil, including BR-116 and BR-101, from 2007 to 2009. An individual's voluntary declination to participate in this study was accepted as one of the exclusion criteria; we also excluded non-Brazilian drivers from the study, although Brazilian drivers carrying cargo to other countries were included. These drivers could be autonomous (owning their own truck and working on demand) or aggregates (truck drivers owning their own vehicles and affiliated with one or more carriers) or employees of large carriers. Several work schedules were thus included in our study, such as scales of 12/12 hours, 8/16 hours, and other less orthodox models, like shift work. This research was approved by the Ethical Committee from Universidade Federal de São Paulo (1597/03).

## Assessment tools

The validated structured sleep questionnaire, the "UNIFESP Sleep Questionnaire" [14], was used to obtain relevant demographic, clinical, and occupational data, including age, current medical conditions, consumption of medications, habitual snoring, smoking status, alcohol intake, use of hypnotic-sedative and psychoactive drugs, sleep duration, pattern, disorders and complaints, psychological disorders, physical activity, working conditions, and accident history. The "Accidents" variable was calculated by including those who answered "yes" to accident involvement related to sleep disorders or somnolence while driving, according to the participants' occupation history.

## Statistical analysis

Average values are given as the mean ± SD. Correspondence analysis (CA) is a multivariate graphical technique designed to explore relationships between 2 or more categorical variables. In this study's context, we used CA to assess the clustering of evaluated potential categorical variables with involvement in automobile accidents, aiming to examine associations between these variables. To build an accident profile with our model we included the following variables: accident involvement related to sleep disorders or somnolence; drug consumption; excessive sleepiness; falling asleep while driving; overnight travel; sleep complaints; and working longer than 9, 12, 14 or 19 hours without rest. Proximal categories suggest an association in the correspondence analysis, meaning that identifying a potential relationship between certain categories indicates the presence of an essentially descriptive phenomenon, i.e., it is not possible to establish cause-effect relationships with this analysis.

We adopted a logistic regression model to identify the odds ratio of accident involvement, adjusted by potential confounders. Both predictors and potential confounders were excluded from the set of categorical variables grouped in the CA. All analyses were performed using the *Predictive Analytics Software* 17.0 version for Windows package (PASW, Inc., Chicago, IL). The level for statistical significance was set at $p<0.05$ throughout.

# Results

All participants were males from 20-70 years age; of the participants, 20.5% were between 20 and 30 years of age, 28.3% were between 31 and 40 years old, 23.9% were between 41 and

50 years old, 16.1% were between 51 and 60 years old, and 4.4% were between 61 and 70 years old. In terms of marital status, 21 participants (10.2%) were single, 148 participants (72.2%) were married, and 9 participants (4.4%) were widowed or divorced. Freelance workers comprised 52.2% of our sample. In terms of the participants' level of education, 102 (50.2%) had less than a high school diploma, 88 (43.3%) had obtained a high school diploma, and 4 (2.0%) had obtained a college degree.

Responses to questions concerning health-related problems, social conditions and working conditions are presented in **Table 1**. The self-reported information indicated hypertension in 17 participants (8.4%), diabetes in 6 participants (3.0%), and cardiovascular ailments in 3 participants (1.5%). Regarding their medication history, 14 participants (6.0%) took sleeping pills, 55 participants (27.1%) took medication to stay awake, mainly the use of amphetamines called "rivets"; Indeed, 84 participants (43%) evidenced the use of alcohol. Finally, the average amount of sleep reported by drivers was 6.6 ± 1.7 hours, with wakeful interludes occurring during sleep periods that totaled an average of 34,3 ± 7.7 minutes and with 10.9% of the drivers reporting a history of leg movements in bed at least 1-2 times a week.

Pertaining to sleepiness and accidents, the subjects reported that the mean duration of their driving hours per day was 13.2 ± 3.6. Specifically, 11.0% of the subjects reported working >9 hours per day, 70.0% of the subjects reported working >12 hours per day, 47.0% of the subjects reported working >14 hours per day and 4.0% of the subjects reported working >19 hours per day. The subjects also reported having slept while driving 1.7 ± 1.4 times in each travel episode and knowing, on average, 3.7 ± 6.3 friends who have fallen asleep at the wheel.

### Risk profile

In **Figure 1**, we can observe variable clusters, according to drivers' responses, that allow us to propose two different profiles. **Profile 1** includes those who reported accident involvement, as well as the respondents who gave positive answers for drug consumption, driving more than 14 to 19 hours at a time without rest, excessive sleepiness, falling asleep while driving and sleep complaints. **Profile 2** includes those who reported no accident involvement, as well as the respondents who answered negatively to sleep complaints, falling asleep while driving, drug consumption and excessive sleepiness.

The CA also showed that certain analyzed variables demonstrated an *eigenvalue* higher than 1.5, including overnight travel, falling asleep while driving, sleep complaints, excessive sleepiness, drug consumption and working more than 9 hours per day **(Table 2)**. These data suggest that these variables appear to be associated with accident involvement and are essential to identifying the two profiles described previously.

Logistic regression analysis demonstrated the importance of these variables for establishing the two profiles **(Tables 3 and 4)**. We observed that the odds of accident involvement were 4 times higher for drivers who traveled overnight. However, there was a protective effect for accident involvement for drivers who worked less than 12 hours per day.

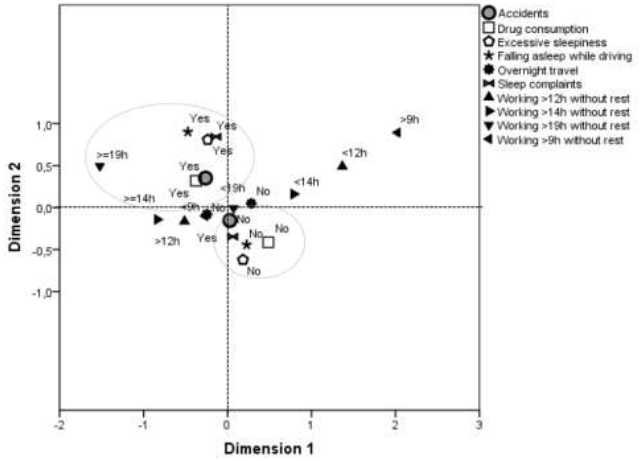


**Figure 1** Correspondence analysis map of accident involvement, truck drivers' habits and truck drivers' sleep quality.

## Discussion

Our results demonstrate the emergence of two distinct professional truck driver profiles. Profile 1 showed that those drivers who answered affirmatively to accident involvement were grouped with respondents who responded affirmatively for drug consumption, driving longer than 14 to 19 hours without rest, excessive sleepiness, falling asleep while driving and sleep complaints. Profile 2 showed that those who reported not being involved in accidents were grouped with respondents who reported no issues in terms of sleep complaints, falling asleep while driving, drug consumption and excessive sleepiness. Additionally, when we evaluated the accident involvement risk profile, we observed that the variable contributing most to the formation of these two profiles was overnight travel, followed by falling asleep while driving and sleep complaints. Our data also demonstrated that the exposure to accidents was 4 times higher for drivers who reported overnight travel. On the other hand, our results also showed a protective effect in terms of accident involvement for drivers who reported working less than 12 hours per day. However, Soccolich et al. [15] have demonstrated that an increased waking time, associated with working hours behind the wheel and extra daily activities contribute to the increased risk of errors, incidents and accidents at the wheel. Indeed, a study including 593 truck drivers identified six factors that could explain the drowsiness at the wheel: excessive daytime sleepiness, long working hours, insufficient sleep duration, longer driving experience, age and sleep disorders [2]. Sleep disorders are currently considered a public health issue due to several well-known negative effects on the general population's health and wellbeing. It is possible to highlight the consequences of these disturbances, which include increased human errors, loss of productivity, and an elevated risk of accidents [16,17]. Conditions involving sleep disorders, chronic sleep deprivation, excessive sleepiness, and shift-work have been related to impaired performance of daily activities, including driving a motor vehicle. Many countries have reported fatal and serious accidents because of inadequate sleep and driver fatigue [4,10,18]. A study of 19 European countries in 2013 reported a

**Table 1** Responses related to health, social conditions and working conditions.

| Variables | % |
|---|---|
| **Health** | |
| Health-related problems | 23.6 |
| Exercise | 30.5 |
| Short sleep | 40.4 |
| Difficulty falling asleep | 16.7 |
| Awakening during the night | 41.4 |
| Bad sleep perception | 71.9 |
| Excessive somnolence during the day | 36.5 |
| Irregular sleep times | 36.0 |
| Would like to improve sleep time | 32.5 |
| Difficultiesin waking up | 12.3 |
| Drowsyupon waking | 15.3 |
| Physical tiredness upon waking | 14.3 |
| Poor quality of sleep | 28.6 |
| Insomnia | 11.8 |
| No sleep dreams | 33.5 |
| Nightmares | 14.3 |
| Waking up withthe feeling of beingsuffocated | 7.4 |
| Warned by someone about frequent pauses in breathing during sleep | 22.2 |
| Frequent snoring | 20.7 |
| Restless sleep | 20.7 |
| Cramps at least 1-2 times a week | 9.9 |
| Leg movement in bed at least 1-2 times a week | 10.8 |
| **Social History** | |
| Unfavorable conditions at home sleep place | 5.4 |
| Unfavorable conditions at work sleep place | 20.9 |
| Alcohol intake | 42.9 |
| Smoking | 22.2 |
| Desire to quit smoking | 17.2 |
| Already took medication to stay awake | 27.1 |
| Naps during work time | 51.2 |
| Naps on the truck | 44.3 |
| It would be useful to put rooms for napping on charts of highways and gas stations so drivers could take 20-minute naps | 41.4 |
| **Work Conditions** | |
| More than one job | 7.4 |
| Shift work | 66.0 |
| Working more than 60 hours per week | 31.5 |
| Have already fallen asleep at the wheel | 32.5 |
| Have a friend who has fallen asleep at the wheel | 64.0 |
| Have already been involved in a car, motorcycle and/or truck accident due to sleep needs | 7.4 |
| Use rest stops every 3 to 4 hours | 45.8 |
| Heavy caloric food ingestion during work | 43.3 |

prevalence of 6,1 to 34,7% of having fallen asleep at the wheel in the previous two years [19]. In Brazil, sleepiness and fatigue are responsible for 20% and over 30% of the accidents that occur on Brazilian highways annually [20]. In 2014, the Brazilian Federal Highway Police reported that that out of a total of 168.593 road accidents, nearly 54.422 had been caused by lack of attention and 10.183 by asleep at the wheel [21].

There is increasing evidence of how sleepiness contributes to causing these accidents in transport systems [22-24]. According to the US National Highway Traffic Safety Administration, drowsiness and fatigue have been identified as causal factors in 1.2-1.6% of all police-reported crashes and 3.6% of all fatal crashes [25]. Another study has shown that approximately 18.0% of traffic deaths are related to sleepy driving [26]. A previous study conducted by our research group has shown that a significant proportion of Brazilian truck drivers suffer from excessive sleepiness, chronic sleep debt and poor quality of sleep [17]. Although the direct consequences of excessive daytime sleepiness on vigilance and reaction time (psychomotor abilities considered essential for driving) are well established [27], the direct effect of sleep disruption on accidents involvement is still unclear. The exact magnitude of this influence is difficult to clarify due to the multi-factorial nature of many crashes and the underreporting of sleepiness by drivers [28,29]. The real concern regarding this issue is that until the last few decades, excessive sleepiness was not considered a major focus in highway driving safety initiatives [2].

The current study corroborates previous findings by demonstrating that truckers with excessive sleepiness are more likely to have a history of accidents. According to our results, drivers who reported excessive sleepiness were associated with those who reported being involved in an accident. This result is also corroborated by the fact that subjects who reported falling asleep while driving and having some sleep complaints were also included in this observed cluster. It is worth noting that overnight travel was the primary contributor to this scenario. Friswell and Williams [9] evaluated two groups of drivers and reported that 29% of commercial vehicle drivers and 17.9% of heavy truck drivers showed excessive sleepiness (ESS> 10), driving 50 hour per week. Additionally, commercial vehicle drivers reported the occurrence of fatigue after 06 hours on the steering wheel. On the other hand, heavy vehicle drivers reported that these feelings started after 11 hours driving. Indeed, this study reported that these fatigue was coincident with a decrease in core temperature i.e., from 13:00 to 18:00 for commercial vehicle drivers and between 02:00 and 06:00 for commercial vehicle drivers. Furthermore, 27.1% of commercial vehicle drivers and 13% of commercial vehicle drivers have crashed due to fatigue related with a long time of driving [9].

Two studies reported that traffic accidents tend to occur at times that coincide with a decline in core temperature, such as around mid-afternoon and from 2:00am to 6:00am, with the latter time frame being the most critical period associated with sleepiness [30,31]. The nadir temperature (approximately 4:00am) coincides with the acrophase of melatonin secretion (approximately 2:00 and 4:00am), both of which increase the sleep pressure and sleepiness in general [32,33]. Sleepiness is regulated by homeostatic and circadian factors and occurs when natural homeostatic sleep pressure accumulated during a period of wakefulness coincides with a circadian trend. Circadian rhythmicity plays an essential role in regulating the sleep-wake cycle [34-36].

As we have reported, these consequences of sleep disturbances may play a critical role in accidents and driving errors. Recent

**Table 2** Accident involvement risk profile.

| | Overnight travel | Falling asleep while driving | Sleep complaints | Accidents | Excessive sleepiness | Drug consumption | Working without rest (h) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | > 9 | >12 h | >14 h | >19 h |
| **Overnight travel** | 1.000 | .004 | -.034 | .140 | -.028 | .157 | .097 | .077 | .146 | .012 |
| **Falling asleep while driving** | .004 | 1.000 | .190 | .029 | .284 | .126 | .115 | .061 | .143 | .055 |
| **Sleep complaints** | -.034 | .190 | 1.000 | -.045 | .129 | .119 | -.015 | -.014 | -.031 | .023 |
| **Accidents** | .140 | .029 | -.045 | 1.000 | .015 | .148 | .025 | -.077 | .051 | .079 |
| **Excessive sleepiness** | -.028 | .284 | .129 | .015 | 1.000 | .152 | -.095 | .077 | .067 | .101 |
| **Drug consumption** | .157 | .126 | .119 | .148 | .152 | 1.000 | .154 | .097 | .201 | .046 |
| **Working > 9 h without rest** | .097 | .115 | -.015 | .025 | -.095 | .154 | 1.000 | .594 | .339 | .077 |
| **Working >12 h without rest** | .077 | .061 | -.014 | -.077 | .077 | .097 | .594 | 1.000 | .570 | .130 |
| **Working >14 h without rest** | .146 | .143 | -.031 | .051 | .067 | .201 | .339 | .570 | 1.000 | .227 |
| **Working >19 h without rest** | .012 | .055 | .023 | .079 | .101 | .046 | .077 | .130 | .227 | 1.000 |
| **Dimension** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Eigenvalue** | **4.456** | **2.929** | **2.458** | **2.045** | **1.749** | **1.674** | **1.588** | **1.351** | **1.187** | **.563** |

studies have shown that other behaviors can also contribute to accident involvement, such as drivers' substance abuse in an attempt to focus their attention and stay awake longer during extensive work hours and/or irregular schedules [37,38]. Our results also revealed drug use as an important behavior that differs between subjects who reported accident involvement and those who did not (of those reporting accident involvement, 70.0% also reported drug use). In this sense, our results reinforce how truck drivers should be considered a priority target group in public policy for preventing illicit drug abuse. A Brazilian study conducted by Leyton et al. [39] including 452 truck drivers found high consumption of psychoactive substances, where 5.8% of drivers showed positive results for amphetamines, 2.2% for cocaine and 1.1% for cannabinoids. Indeed, Di Millia et al. [4] emphasized that the use of alcohol and illicit drug to stay awake and avoid fatigue can directly impact the fatigue.

Also consistent with previous findings, we observed that the mean duration of hours driven per day was more than 9 consecutive hours [17]. More than two-thirds of the drivers in our study reported >12 hours per day of driving and almost 50.0% were assumed to habitually drive more than 14 hours per day. Economic incentives may entice drivers to drive long hours in the trucking work segment, and current regulations restricting the working hours of commercial motor vehicle drivers in Brazil are inadequate at curbing this practice.

These numbers are alarming because this extended period of driving time includes often-fatal overnight working times. In addition to increasing the likelihood of accidents, according to our results, traveling overnight may also boost the number of fatalities because research [40] has shown that accidents caused by sleepiness occur mainly on long trips (63.8%), often at night (40.9%). Indeed, our study emphasized how overnight travel can lead to an increased accident risk that is 4 times greater than normal, highlighting how sleep quality, sleep habits and the resulting excessive sleepiness contribute to the most identifiable and preventable cause of accidents in all modes of transportation [41]. These results have important implications for preventing accidents among these workers. In this context, our data also highlight that driving fewer than 12 hours per day had a protective effect in this population.

It is well reported in the literature that going over 17 hours without sleep impairs cognitive performance [42]. Dawson and Reid [43] found that 17-19 hours of sleep deprivation resulted in decreased success in cognitive task performance, which is equivalent to the effects of a 0.05% blood alcohol concentration. In Brazil, the new regulation (law number 12.619 of 2012/apr/30) reports a maximum of 12 hours of driving, with rest and meal intervals. Until 2011, regulations regarding the hours of rest and working time for professional truck drivers had not been defined. In 2012, law 12.619 was approved, mandating thirty minutes of rest for every four hours of uninterrupted drive time at the wheel, as well as one hour per meal, an interval of eleven hours of rest every 24 hours and thirty-five hours of weekly rest [1].

Our results showed that the consumption of psychoactive drugs was related with accident involvement. According to previous findings, the use of psychoactive drugs among truck drivers is

**Table 3** Accident involvement profile description.

| | | Accident involvement | | No Accident involvement | |
|---|---|---|---|---|---|
| | | F | % | F | % |
| **Overnight travel** | **Yes** | 68 | 61.3 | 29 | 35.4 |
| | **No** | 43 | 38.7 | 53 | 64.6 |
| | **Total** | 111 | 100.0 | 82 | 100.0 |
| **Sleep Complaints** | **Yes** | 33 | 28.7 | 25 | 29.1 |
| | **No** | 82 | 71.3 | 61 | 70.9 |
| | **Total** | 115 | 100.0 | 86 | 100.0 |
| **Working without rest** | **<9 h** | 112 | 99.1 | 63 | 74.1 |
| | **>9h** | 1 | 0.9 | 22 | 25.9 |
| | **Total** | 113 | 100.0 | 85 | 100.0 |
| | **<12 h** | 1 | 0.9 | 53 | 62.4 |
| | **>12 h** | 112 | 99.1 | 32 | 37.6 |
| | **Total** | 113 | 100.0 | 85 | 100.0 |
| | **<14 h** | 17 | 15.0 | 85 | 100.0 |
| | **>14 h** | 96 | 85.0 | ——— | ——— |
| | **Total** | 113 | 100.0 | ——— | ——— |
| | **<19 h** | 104 | 92.0 | 85 | 100.0 |
| | **>19 h** | 9 | 8.0 | ——— | ——— |
| | **Total** | 113 | 100.0 | ——— | ——— |
| **Falling asleep while driving** | **Yes** | 46 | 40.4 | 20 | 23.8 |
| | **No** | 68 | 59.6 | 64 | 76.2 |
| | **Total** | 114 | 100.0 | 84 | 100.0 |
| **Excessive sleepiness** | **Yes** | 56 | 48.3 | 32 | 36.8 |
| | **No** | 60 | 51.7 | 55 | 63.2 |
| | **Total** | 116 | 100.0 | 87 | 100.0 |
| **Drug consumption** | **Yes** | 81 | 69.8 | 33 | 37.9 |
| | **No** | 35 | 30.2 | 54 | 62.1 |
| | **Total** | 116 | 100.0 | 87 | 100.0 |

**Table 4** Odds ratios according to observed profiles.

| | | Confidence interval | | | |
|---|---|---|---|---|---|
| **Accidents involvement profile** | **OR** | **Lower** | **Upper** | ***p*** | **Wald** |
| **Excessive sleepiness** | 1.129 | .404 | 3.154 | .817 | .053 |
| **Sleep complaints** | 1.546 | .535 | 4.467 | .421 | .648 |
| **Overnight travel (yes)** | 4.778 | 1.734 | 13.165 | .002 | 9.150 |
| **Working without rest (<12 h)** | .002 | .001 | .022 | .001 | 28.518 |
| **Falling asleep while driving** | 3.022 | .921 | 9.907 | .068 | 3.331 |

common. A toxicological study of truck drivers in Brazil found that 1.4% were positive for alcohol, 0.6% were positive for amphetamines, 0.6% were positive for cocaine and 0.4% were positive for tetrahydrocannabinol [44]. Another similar study conducted in France with 1,000 drivers found, by urine tests, 85 cases of cannabinoids, 41 of opiates, 03 of amphetamines, 01 of cocaine, 18 of buprenorphine, 05 of methadone, 04 of benzodiazepines and the presence of ethanol in 50 cases [45]. Furthermore, Gjerde et al. [46] reported that fatal accidents in total and single vehicle accidents were associated with the use of amphetamine [OR: 57.1(95% CI: 27.3-119.5)] and methamphetamine [OR: 49.2 (95% CI: 16.5-146.9)] in drivers in Norway.

In summary, our results confirmed our hypothesis and highlighted how adequate sleep habits, as well as the consequences related to sleep disturbances, are associated with drug consumption and accident involvement by truck drivers in our study. These data reinforce the need to be more attentive to the truck driver population because they have a high propensity for accidents. The challenge for future research is to develop drowsy driving-detecting technology that could reduce the risks of excessive sleepiness in this population because there is a lack of reliable, objective tests for measuring driver sleepiness.

We noted some important limitations of this study. We evaluated a relatively small number of truck drivers. Additionally, considering that our study included only truck drivers from certain roads in Brazil, we can only guarantee the internal validity of these results within these restrictions. For this reason, there is a need for additional studies with larger samples that include truck drivers from several regions, and possibly from other countries, to achieve external validity.

## Authorship

- **Conception and Design:** Francieli S Ruiz e José Carlos de Souza. Both authors will share the first authorship of this manuscript.
- **Acquisition of Data:** José Carlos Souza, Andrea Maculano Esteves, Renan da Cunha Soares Junior, Amaury Barreto.
- **Analysis and Interpretation of Data:** Francieli S Ruiz, José Carlos Souza, Fernanda V Narciso, Andrea Maculano Esteves, Renan da Cunha Soares Junior, Amaury Barreto, Vagner Raso, Sergio Tufik, and Marco Túlio de Mello.
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