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Effects of driver work-rest patterns, lifestyle and payment incentives on long-haul truck driver sleepiness

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ABSTRACT

The aim of the study is to identify and model the role of payment incentives, driver work-rest patterns and other lifestyle habits influencing the drowsy driving behavior among long-haul truck drivers. To achieve this aim, this study targeted two main objectives: (1) to examine the significant differences between the groups of drowsy and non-drowsy drivers based on the opportunities of monetary incentives and (2) to examine the role of different factors: driver demographics, work-rest patterns, lifestyle and occupational characteristics particularly incentives associated with driving in causing driver sleepiness among Indian truck drivers. The study is based on interview responses from 453 long-haul truck drivers approached in three Indian cities – Mumbai, Indore and Nagpur.

Initial principal component analysis of the responses related to financial incentives (occupational characteristics) resulted into two correlated factors: (i) willingness to earn extra payments if offered (WEP) and (ii) incentives available in the current driving experience (ICD) that influence driver work-rest patterns and alertness while driving. Kruskal-Wallis test showed a significant difference among the groups of sleepy and non-sleepy drivers due to these factors (WEP and ICD). Finally, a logistic regression model showed that long driving duration, working days per week, rest patterns, insufficient sleeping hours and history of violations were found significantly associated with drowsy driving among the long-haul truck drivers. Increase in consumption of caffeine and tobacco indicated reduction in driver alertness. According to the model results, the odds of drowsy driving were 77% less for drivers between 46 and 55 years compared to the young drivers (<25 years). Driving under the influence of financial incentives was observed to increase the odds of falling asleep by 1.58 times among the truck drivers. This was apparently the most interesting and intriguing result of the study indicating the need for further research on the influence of financial or socio-economic motivations to sleepiness.

1. Introduction

Indian trucking industry caters to 65% of total freight transport in India (Asian Institute of Transport Development (AITD), 2015; Raghuram, 2015). With increase in globalization, the demand of road freight transportation is expected to increase further. Truck drivers who form the human backbone of this industry are often involved in long distance trips compromising

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their rest or sleep requirements. Indian trucks travel at an average speed of 20–40 km/h and average distance travelled by Indian truck drivers is about 250–300 km per day which is less than half the daily mileage of the US and UK truck drivers (Medvedev, Shome, Seth, & Misra, 2014). Poor road and maintenance conditions in India not only reduce the mileage but also add to driver health and safety problems (Asian Institute of Transport Development (AITD), 2000). Indian truck drivers often drive without any adequate rest which might be the cause of their fatigue and higher involvement in accidents (Raghuram, 2015). As stated in the Fatality Analysis Reporting System (FARS) report, 11.2% of all road crashes during 2015 involved at least one large truck in the US (Highway Traffic Safety Administration & Department of Transportation, 2015). In a report by Australian Transport Council (2011–2020), 20–30% of fatalities on the roads are as a result of fatigue and drowsy driving (National Road Safety Strategy, 2011). The situation is more severe in developing countries such as India. The National Crime Record Bureau (NCRB) of India recorded that trucks used for transporting commercial goods accounted for 19.4% of the total deaths due to road accidents in 2015 (National Crime Records Bureau, 2015). Amongst the total road accident fatalities, 60% were owed to erroneous driver behavior during overtaking maneuvers, distraction or lack of alertness, etc.

In the context of driver behavior, the terms 'sleepiness', 'drowsiness' and 'fatigue' are used interchangeably in previous studies to denote driver's level of alertness or driver exhibiting any symptoms of falling asleep at the wheel (e.g. Anund, Kecklund, & Åkerstedt, 2011). Sleepiness or sleep propensity is one's tendency to fall asleep as a result of imbalance or alterations in sleep-wake mechanism (Johns, 2000). Phillips, Kecklund, Anund, and Sallinen (2017) defined fatigue as "the body–mind response to sleep loss or prolonged physical or mental exertion". In case of truck drivers, long hours of wakefulness, irregular shifts disturb the sleep-wake mechanism resulting in driver sleepiness. However, the conditions like stress and lack of proper sleep among truck drivers may lead to exertion causing fatigue over the long journeys (Phillips, 2015). Fatigue or sleepiness among drivers is marked by various symptoms like frequent blinking, yawning, difficulty remembering the past few miles driven, drifting from one's lane etc. These symptoms are commonly termed as 'lapses' in the standard 'Driver Behavior Questionnaire' (e.g. Bener, Crundall, Haigney, Bensiali, & Al-Falasi, 2007; Reason et al., 1990). The current study has also used these terms as synonymous to each other. Symptoms of fatigue and drowsiness can cause negative influence on driving (Al-Houqani, Eid, & Abu-Zidan, 2013; Alonso, Esteban, Useche, & De Cózar, 2016; McCartt, Rohrbaugh, Hammer, & Fuller, 2000). Sleepiness at the wheel increases the odds of accidents (Bener et al., 2007; Blower, Green, & Matteson, 2010; Sullman, Meadows, & Pajo, 2002). Drowsy driving can lead to severe property damages, injuries and fatalities, but is usually under-reported (Anund et al., 2011; Sagberg, 1999; Tefft, 2012). Many previous studies have focused on drowsy driving problem among truck drivers which suggest driver demographics, lifestyle and work-rest patterns are the main factors that contribute to driver alertness (confer Table 1) (Castillo-Manzano, Castro-Nuño, & Fageda, 2016; Duke, Guest, & Boggess, 2010; Kanazawa, Suzuki, Onoda, & Yokozawa, 2006; Meng et al., 2015; Papadakaki, Kontogiannis, Tzamalouka, Darviri, & Chliaoutakis, 2008; Teoh, Carter, Smith, & McCartt, 2017; Tzamalouka, Papadakaki, & Chliaoutakis, 2005).

In India, the work-rest periods for drivers of goods carrying heavy vehicles are governed by the 'Hours of Service (HOS)' rules under 'Motor Transport Workers (MTW) Act, 1961' (Ministry of Labour & Employment, 2008). Given the poor road conditions in India, the maximum permitted hours of driving according to this act is eight hours a day which is relatively less than that in developed nations such as the US or the EU (confer Table 1). The working hours in India are extendable to a maximum of 10–12 h on special occasions and 48 h a week or in no case beyond 54 h a week. The driver shall have a rest period for a minimum of nine hours before a trip on a new working day. The hours of work shall not spread for more than two shifts a day. The details of HOS rules and its enforcement actions in India are compared with the US and the EU in Table 1.

The enforcement actions in India are neither very stringent (British Columbia Truckers Association (BCTA), 2013; Urie, Velaga, & Maji, 2016) nor specific for example the number of days for which the logbook record has to be maintained is

Table 1
'Hours of service' rules for heavy vehicle/truck drivers in India compared to other developed countries.

Hours of service rules	India	US	EU
Reference	Ministry of Labour & Employment, 2008	Federal Motor Carrier Safety Administration, 2015	Road Safety Authority, 2006
Max. driving hours	8 h/day	11 h/day	9 h/day
Extendable driving hours * on '*special occasions*'	10 h out of maximum 12 h on duty	13 h out of maximum 14 h on duty	10 h (maximum twice a week)
Maximum weekly driving hours	54 h/week	60 h/7 days or 70 h/8 days	56 h/week 90 h/fortnight
Minimum Rest Time (Continuous sleep time)	9-hours/day and 1-day/week	8–10 hours/day	9–11 h/day 45 h/week
In-between Breaks	30 min every 5 h of consecutive driving	Minimum 30 min in 8 h of consecutive driving	45 min break (or two breaks of 15 + 30 min) every 4.5 h
Enforcement regulation*	Logbook record	Logbook/Electronic logging device (ELD): record over last 8 days.	Tachometer record sheets over last 28 days
Penalty for violation	Imprisonment (3 months) and/or fine	Suspension from service and/or fine	Suspension from service and/or fine

Note: *The data regarding enforcement of this law or statistics of its violations among Indian truck drivers is not openly accessible.

not fixed as compared to other countries (Table 1). Further, the MTW Act which governs the HOS rules in India is applicable only when the undertaking employs five persons or more (Asian Institute of Transport Development (AITD), 2015; Government of India & Ministry of Labour and Employment, 1988). The Indian trucking industry is dominated by small truck owners, 75–80% own less than five trucks (Asian Institute of Transport Development (AITD), 2015; Indian Institute of Management Calcutta, 2009; Medvedev et al., 2014; Raghuram, 2015). It is assumed that the poor economic conditions of Indian truck drivers may also motivate them to falsify their logbooks or work more hours to earn extra monetary benefits (British Columbia Truckers Association (BCTA), 2013). Therefore, despite these regulations, violation of work-rest period regulations can be expected in India leading to sleep deprived and fatigued driving. However, it is evident from the literature that very few studies on driver fatigue and drowsiness while driving have been conducted in the developing countries like India.

Some previous studies have found economic factors such as payment based on trip length or monthly flat rate as factors influencing fatigue, but, no such association has been detected with driver sleepiness (Thompson & Stevenson, 2014; Thompson, Newnam, & Stevenson, 2015). This study targets to evaluate the influence of additional economic motivations such as productivity-based incentives (e.g. early or on-time deliveries) that may motivate the truck drivers to work for long hours, compromising their need for adequate rest and sleep. Therefore, the aim of this study is to evaluate the role of driver lifestyle and other economic factors on the probability of driver sleepiness at the wheel. To achieve this aim, this study has two main objectives: (1) to examine if there is a significant difference between group of drivers falling asleep while driving and other drivers based on opportunities for monetary incentives and (2) to examine the role of incentives associated with driving and influence of other work and lifestyle factors on driver sleepiness.

2. Previous research

There are two approaches used in the literature to study the drowsy driving behavior among long-haul truck drivers: (1) Naturalistic driving studies and (2) Questionnaire-based surveys. Naturalistic driving studies have been adopted by very few researchers in the past (Blanco et al/, 2011; Chen, Fang, Guo, & Hanowski, 2016; Sparrow et al., 2016). Whereas, questionnaire-based surveys or analyzing past crash records have been popularly used by the researchers, because these are safer data collection methods and cover a larger population sample (Kanazawa et al., 2006; McCartt et al., 2000; Pérez-Chada et al., 2005; Sullman et al., 2002).

Various analysis techniques have been used by the researchers to study the effects of different lifestyle and sleep-related factors on the probability of drowsy driving and associated crash risk. For instance, Girotto, de Andrade, Gonzalez, and Mesas (2016) and Sadeghniiat-haghighi, Yazdi, and Mohammad (2016) used multinomial logistic regression and Häkkänen and Summala (2001), Meng et al. (2015), Papadakaki et al. (2008) and Tzamalouka et al. (2005) used logistic regression. Chi-square test (Meng et al., 2015; Williamson & Friswell, 2013), Kruskal-Wallis test (Philip et al., 2002; Sabahiah, Sukor, Tarigan, & Fujii, 2017), Spearmen correlation (Philip et al., 2002), factor analysis (McCartt et al., 2000; Sullman et al., 2002; Tsao, Chang, & Ma, 2017), multivariate analysis of covariance (MANCOVA) (Thompson & Stevenson, 2014) and Agent-Based Modeling (ABM) (Thompson et al., 2015) are also some of the commonly used analysis techniques.

In contrast to India, the previous studies across the globe have elucidated the dimensions of drowsiness problem among commercial or Heavy Vehicle (HV) drivers to some extent (Castillo-Manzano et al., 2016; Duke et al., 2010; Kanazawa et al., 2006; Meng et al., 2015; Teoh et al., 2017). Based on the literature, the major contributing factors to drowsiness problem among drivers are discussed in the following sub-sections. Relevant hypotheses drawn from the previous research findings are proposed to be examined in context of Indian truck drivers in the current study.

2.1. Driver demographics

Younger and less experienced drivers are generally associated with higher risk of drowsy driving (Barr, Yang, Hanowski, & Olson, 2005; Häkkänen & Summala, 2001; Smith, Horswill, Chambers, & Wetton, 2009). According to Duke et al. (2010), the drowsiness symptoms were minimum among the middle-aged drivers compared to the young and elderly drivers. The association of driver education level with his alertness or fatigue has been a topic of ambiguity. A higher level of education among licensed drivers are associated with increased mental fatigue and hence increased frequency of drowsy driving (Di Milia et al., 2011; McCartt, Ribner, Pack, & Hammer, 1996; Newnam, Mamo, & Tulu, 2014). On the contrary, Di Milia et al. (2011) and Watt et al. (2000) found that the less/uneducated groups exhibit greater physical fatigue and hence higher risk of drowsy driving. Zhang, Yau, Zhang, and Li (2016) found that the education level of truck drivers did not contribute to their risky driving behavior. Driver education may help them understand the risks involved with overtime and inappropriate rest schedules, thus leading to the following hypothesis.

Hypothesis 1. In case of truck drivers, higher education level may reduce driver involvement in drowsy driving.

Married couples tend to share the domestic burden, thus marriage may lessen the consequent mental and physical fatigue on drivers (Di Milia et al., 2011). However, it seems likely that the poor economic conditions, low literacy and unemployment may burden the drivers in India with financial responsibility of their family members. In order to meet the financial needs of

dependents/family Indian drivers might prefer to compromise their resting time for extended work hours for incentives. Thus, in context of India, family responsibility is a more appropriate variable than marital status to influence driver alertness. Therefore, the following hypothesis is proposed.

Hypothesis 2. Family responsibility may lead to long working hours and greater exposure to drowsy driving risks.

2.2. Driver lifestyle and drowsiness

2.2.1. Work-rest schedule

The long working hours and inadequate sleep have been identified as the main reasons for sleepiness while driving among freight vehicle drivers (McCartt et al., 2000; Papadakaki et al., 2008; Sadeghniiat-haghighi et al., 2016; Tzamalouka et al., 2005). Therefore, an adequate sleep of minimum seven hours (7 h) a day is recommended for safer driving practices (Johnson et al., 2015; Wheaton, Chapman, Presley-Cantrell, Croft, & Roehler, 2013). Long sleepers (>10 h) as well as insufficiently sleeping drivers ($\leq$6 h) show an increased risk of drowsy driving (Maia, Grandner, Findley, & Gurubhagavatula, 2013). Chen et al. (2016) studied the sleep patterns among a group of commercial drivers and found that high fatigue and drowsiness were associated with lack of sleep specifically between 1 am to 5 am. The rotating shift workers are involved in driving and other activities during this period. Thus, the shift workers are expected to be at a greater risk of accidents due to drowsiness compared to regular workers (Johnson et al., 2015). Morning rush hours, post-lunch or post mid-night periods are certain safety-critical timings, which are associated with low circadian rhythms and high decrement in alertness while driving (Aidman, Chadunow, Johnson, & Reece, 2015; Matthews et al., 2012; Zhang et al., 2016; Zhang, Yan, Wu, & Qiu, 2014). The accident risk increases as the duration of driving increases, especially beyond 4 h of continuous driving (Lin, Jovanis, & Yang, 1984). As stated by the HOS rules in India, it is mandatory for the drivers to take adequate rest breaks while driving and also before starting the shift (confer Table 1). Involvement of drivers in non-driving activities such as loading-unloading or waiting in queues during the work period can increase driver fatigue (Williamson & Friswell, 2013). Based on the influences of work-rest schedules on driver alertness, the following hypothesis is examined in the current study.

Hypothesis 3. The violations of HOS rules for heavy vehicle drivers and increase in duration of driving could be an important reason for drowsy driving among Indian truck drivers.

2.2.2. Other lifestyle habits

Lifestyle habits of freight vehicle drivers have significant effects on their subsequent alertness. Smoking and caffeine consumption are known to be popular measures adopted by the drivers to maintain adequate alertness while driving (Tzamalouka et al., 2005; Cantor, Corsi, Grimm, & Ozpolat, 2010; Pérez-Chada et al., 2005). The need for consuming caffeinated beverages to stay alert increases with driver drowsiness and fatigue while on duty (Howard et al., 2014; Johnson et al., 2015; Watling, Armstrong, Obst, & Smith, 2014). Habit of alcohol consumption negatively influences the driver's sleep quality and quantity leading to problems such as excessive daytime sleepiness and fatigue while driving (Brower, 2009; Ronen et al., 2010). Avoiding alcohol even the night before the drive is considered as a good precaution to avoid risks of drowsy/fatigued driving (Nordbakke & Sagberg, 2007). Exercise and physical activities are believed to improve the quality of sleep (Chen et al., 2016; McCartt et al., 2000). Adequate consumption of water is also believed to help the driver stay alert (McKernon, 2008; Nordbakke & Sagberg, 2007; Pylkkönen et al., 2015). However, the professional long-haul HV drivers may rarely find time to do anything more than maintaining an active posture on the driving seat and staying hydrated throughout the journey to remain alert and active. Therefore, the following hypothesis is proposed.

Hypothesis 4. Increased need for consumption of caffeinated beverages, alcohol or smoking may indicate the risks of drowsy driving among drivers and sufficient water intake and physical exercise are expected to have a positive influence on driver alertness.

2.3. Incentives and work-rest pattern

According to the World Health Organization (WHO) report, people from poor socioeconomic background are more likely to be involved in road-accidents (World Health Organization, 2013). In a developing country like India, the economic incentive or monetary benefits can also influence the driving hours and related safety of drivers. The economic factors such as payment based on the length or duration of the trip influence the safe driving behavior of commercial vehicle drivers (Campos Monteiro, Peñaloza, Pinto, del Denegri Coria & Orellana Calderón, 2015; Thompson & Stevenson, 2014; Thompson et al., 2015; Williamson and Friswell, 2013). The work duration can be inclusive of driving and non-driving tasks such as waiting in queues and other subsidiary works like loading/unloading activities, upkeep, and maintenance of the vehicle. Williamson and Friswell (2013) and Tzamalouka et al. (2005) found that payment incentives for non-driving duties (for example, waiting idly in queues during the working hours) have been significantly associated with higher fatigue levels among commercial HV drivers. Drivers tend to compromise their rest breaks to meet the arrival time windows (Morrow

& Crum, 2004; Williamson & Friswell, 2013), incentivizing the arrival windows may put an additional pressure on drivers to drive for long hours. Due to such work pressure, drivers may have poor sleep quality which results in increased speeding offences (Tseng, Yeh, Tseng, Liu, & Lee, 2016). The drivers tend to adopt shorter routes over an original route or reroute to traffic disturbances with the intention of saving fuel and time (Dogan, Steg, & Delhomme, 2011; Ericsson, Larsson, & Brundell-Freij, 2006). The intention of saving fuel is also associated with saving money (Lauper, Moser, Fischer, Matthies, & Kaufmann-Hayoz, 2015). However, preferring the shorter uncomfortable routes to save time and fuel may cause additional fatigue among drivers given the poor road conditions in India (Raghuram, 2015). Therefore, providing opportunities that offer additional payment incentives or monetary benefits to drivers for working by compromising their rest needs encourage the situations of sleepy and fatigued driving. Such economic factors might be responsible for high variants of the level of fatigue and drowsiness experienced by the HV drivers, but, have received limited attention in the previous research. Therefore, the following hypothesis is proposed to be examined in this study.

Hypothesis 5. Accepting opportunities for earning incentives can increase the risks of drowsy driving among truck drivers.

3. Material and methods

3.1. Data collection

The data was collected using a questionnaire survey. The survey was pilot tested with 20 truck drivers before the actual survey to check its language comprehensiveness. Hence, necessary modifications were made in the final questionnaire. The actual survey was conducted with 490 long-haul truck drivers through face-to-face interviews on routes connecting to three Indian cities (Mumbai, Nagpur, and Indore). The drivers who did not have valid driving license or provided incomplete responses to dependent variable (did not respond to instances of falling asleep while driving) and invalid responses to certain significant questions (e.g., a driver reporting 14 h of driving on-duty out of self-reported work duration of only 12 h in a day) were rejected. Therefore, only 453 samples which contained complete and valid responses were included in the analysis.

3.2. Procedure

The survey was conducted between March and May 2017. The participation in the survey was entirely voluntary and non-compensated. The surveyors approached the truck drivers for interviews at some specific locations on major freight routes in the outer locations of the cities (highway eateries, rest locations, destinations, etc.). The surveyors began the survey after confirming the willingness of the drivers to spare approximately 30 min for the interview. The drivers were then briefed about the aim of the survey. The survey was continued with them if they were long-haul drivers (driving a minimum of 200 km per day).

3.3. Questionnaire description

The questionnaire used in this survey consisted of measurements for driver demographics, work-rest pattern, other lifestyle factors, payment characteristics and safety-critical events due to driver drowsiness. Some sections such as identification of drowsy lapses were adopted with minor modifications from the Driver Behavior Questionnaire (DBQ) used in previous studies (Reason et al., 1990; Sullman et al., 2002; Williamson & Friswell, 2013 etc.). Based on the literature (Table 2), the detailed questionnaire was divided into the following sections to collect information about the independent variables in the study:

(a) *Driver demographics:* It contained details like age, experience (years of holding a professional truck driving license), education, family responsibility, and body mass index (BMI) in kg/m^2.
(b) *Work-rest pattern:* This section included information about driver's work-rest pattern such as the duration of work (driving and non-driving activities such as loading, unloading, waiting idly in queues at the loading-unloading sites, etc.), driving and sleeping per day, interval as well as the purpose of breaks within the driving schedule, type of work shift (fixed or rotating shifts), day-time or night-time driving.
(c) *Other lifestyle habits:* This section consisted of driver responses about the consumption of tobacco/cigarettes, intake of alcohol, caffeine/tea beverages and water consumed every day while driving or on-duty to stay alert.
(d) *Payment incentives*: Based on the literature in Table 2, additional questions were designed to identify the role of payment incentives (refer Appendix A). The questions were provided with different situations related to payment and its influence on driver working hours and driver actions. The situations indicating either the likeliness or current practice of availing opportunities to earn incentives at the cost of ignoring rest requirements were asked. For example, the questions included: "Will you prefer to take night shift (8 pm–8 am) over day shift for any additional payment?", "Do you receive any financial reward for early or on time arrivals?"

Table 2
Factors influencing the risks of driver drowsiness/fatigue.

S. No.	Factor/variable	Studied by	Results from previous findings
	Dependent variable		
	Self-reported instances of falling asleep or feeling drowsy at the wheel		Associated with crash risk due to drowsy driving
	Demographic factors		
1.	Age	Barr et al., 2005; Häkkänen & Summala, 2001; Duke et al., 2010; Otmani, Roge, & Muzet, 2005	Risk of drowsy driving shows a u-shaped curve with age.
2.	Highest education level completed	- Di Milia et al., 2011; McCartt et al., 1996; Newnam et al., 2014 - Di Milia et al., 2011; Barr et al., 2005; Sullman et al., 2002; Watt et al., 2000 - Zhang et al., 2016	- Higher educated groups experience greater mental fatigue - Uneducated/less educated groups exhibit greater physical fatigue. - Insignificant in predicting driver sleepiness at the wheel.
3.	Family/Marital status	Di Milia et al., 2011	Marriage/Spouse may lessen the fatigue of drivers
4.	Driving experience (in years)	Girotto et al., 2016; Sagberg, 1999	Low experience is associated with higher risk of crashes due to drowsy driving.
5.	Body mass index (BMI)	- Mills, Kim, Bardwell, Hong, & Dimsdale, 2008; - Di Milia et al., 2011; Chen et al., 2016	- Higher BMI increases fatigue. - Increased BMI is associated with increased risk of crashes
	Work-rest pattern		
6.	Duration of work	Papadakaki et al., 2008; Tzamalouka et al., 2005; McCartt et al., 2000; Sadeghniiat-haghighi et al., 2016; Di Milia et al., 2011; Meng et al., 2015; Häkkänen and Summala, 2001	Long and hectic work schedules increase the odds of driver drowsiness
7.	Type of work-shift	Adams-guppy & Guppy, 2003; Sadeghniiat-haghighi et al., 2016; Johnson et al., 2015	Night shift and rotating shifts increased the risks of drowsy driving behavior
8.	Driving time of day	Zhang et al., 2014; Matthews et al., 2012; Aidman et al., 2015; Chen et al., 2016; Häkkänen and Summala, 2001; Williamson & Friswell, 2011	Most tiring time of day for drivers: Post lunch, after midnight (1 am–5 am)
9.	Intermediate breaks	- Williamson, Feyer, & Friswell, 1996; Lin et al., 1984; - Thompson et al., 2015	- More frequent breaks indicate more tiredness among drivers - Each hour of driving without breaks over 4 h adds to fatigue related crash risk
10.	Duration of sleep	Maia et al., 2013; Wheaton et al., 2013; Johnson et al., 2015; Chen et al., 2016	Short sleep (<7 h) increases the odds of driver drowsiness
11.	Non-driving work period	Blanco et al., 2011; Williamson & Friswell, 2013	Additional non-driving activities during work period can increase tiredness among truck drivers.
	Other Lifestyle factors		
12.	Caffeine/tea intake per day	Watling et al., 2014; Howard et al., 2014; Johnson et al., 2015; Philip et al., 2002	Consumption of caffeinated beverages increases with driver drowsiness and fatigue
13.	Physical exercise or activities	Chen et al., 2016; McCartt et al., 2000	Physical activities are believed to improve the quality of sleep
14.	Alcohol consumption	Brower, 2009; Ronen et al., 2010; Nordbakke & Sagberg, 2007	Leads to poor sleep quality and easily prone to fatigue.
15.	Smoking/tobacco intake	Tzamalouka et al., 2005; Cantor et al., 2010	Smoking is adopted to increase alertness
16.	Water intake while driving	Nordbakke & Sagberg, 2007; McKernon, 2008; Pylkkönen et al., 2015	Appropriate water intake helps to increase driver alertness.
	Payment related factors		
17.	Payment type: trip based (by km or by output) or time based	Williamson & Friswell, 2013; Thompson et al., 2015; Thompson & Stevenson, 2014	Drivers 'paid by trip' did longer hours of work had less sleep and were more likely to experience fatigue.
18.	Overtime and longer trips	Di Milia et al., 2011; Sadeghniiat-haghighi et al., 2016; Campos Monteiro et al., 2015	Incentives for overtime encourage extended hours of work and increased driver fatigue
19.	Economic incentives for non-driving works	Blanco et al., 2011; Williamson & Friswell, 2013	Remuneration for non-driving activities encourage longer hours of work and driver fatigue Drivers paid for waiting in queues engaged in lengthy trips
20.	Incentives and arrival windows	Williamson & Friswell, 2013; Morrow & Crum, 2004	Arrival time pressures during the trip
21.	Economic incentives for overtime & lengthy trips	Arnold et al., 1997; Tsao et al., 2017	Economic rewards for overtime increase the odds of driver fatigue
22.	Driving actions and saving fuel	Ericsson et al., 2006; Dogan et al., 2011; Lauper et al., 2015	Motives of saving fuel influences the driving actions such as rerouting to shorter routes or traffic disturbances.
23.	Speeding	Tseng et al., 2016	Overtime leads to fatigue and poor sleep quality which can cause speeding offences

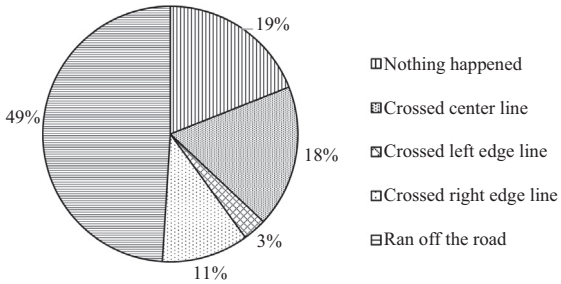

Fig. 1. Effect of falling asleep at the wheel on driving as experienced by the drivers (N = 90).

(e) *Safety-critical events (SCEs):* This section included information about experiences of drowsy driving and safety related events. The drivers were asked about their history of drowsy lapses while driving (“how often have you felt drowsy with symptoms such as frequent yawning, or no clear recollection of the road you just travelled or difficult to concentrate due to sleep?”, “have you ever fallen asleep while driving the heavy vehicle in the past five years?”). They were also asked about the effect of such lapses on their driving (ran off the road, nothing happened, etc. confer Fig. 1) and their history of at-fault accidents due to fatigue or drowsiness in the last five years (i.e., have you been involved in any at-fault accident/near miss crash due to drowsy driving).

3.4. Descriptive statistics

The details of drivers and their lifestyle characteristics are presented in Tables 3 and 4. Most of the drivers in the current sample belong to the age groups 26–35 years (47.9%) and 36–45 years (30.9%) and therefore, corresponding ranges of experience of 5–10 years (42%) and 10–15 years (26.7%) were identified. 14.3% were novice drivers having experience below five years. It is mandatory for the truck drivers to have a minimum qualification of ‘eighth standard’ to acquire the license for driving a commercial vehicle (Central Motor Vehicles Rules, 1989); however, the sample shows 19.4% cases of its violation. In India, the system of joint families still prevails and therefore, sometimes high financial responsibilities fall on few working people in the family. The average household size in India is 4.9 which is almost double the average household size (2.1–2.5) in majority of western developed nations (Department of Economic and Social Affairs, 2017). In the current sample, around 85% of drivers reported that either they have family responsibility or they are the sole earners in the family. Also, 81% of the drivers were married in the current sample.

Drivers reported driving for an average of 9 h (SD = 2.26) out of average 13.6 (SD = 5.35) hours of on-duty daily for almost all seven days a week (confer Table 3). However, in actual practice, they might take up long continuous drives within a week and then rest for consecutive 2–3 days, which makes the actual hours of driving more than 9 h on a working day. Most drivers worked in irregular shifts (64%). Around 36% drove during day-time (8:00 am-lunch) and 23% during night time (8:00 pm to 1:00 am). Most of the drivers took breaks only for taking meals (42%) and very few for rest (3%) while driving. 36% of drivers reported that they sleep only up to 6 h every day; and merely 43% reported taking an adequate sleep of 6–8 h. Around 40% drivers believed that the rest time they get is insufficient to alleviate their fatigue. 77% drivers received a flat rate fixed monthly salary and remaining based on either trip length or on the delivery of products. Mean BMI of drivers was 23.26 (SD = 4.47) and mostly did not engage in any physical exercise in their routine. 17% reported drinking alcohol, 46% reported smoking or intake of tobacco daily and 75% consumed caffeinated drinks minimum three times a day to alleviate fatigue during driving, while only 35% preferred consuming sufficient water (minimum of 2 L per day) which helps to remain alert.

A total of 90 drivers reported that they fell asleep while driving in the course of the last five years and 93 reported feeling drowsy while driving at least twice a month. Out of these 90 drivers, 18% reported that they crossed the center line while driving asleep, and the majority of drivers (49%) ran off the road (confer Fig. 1). This indicates the safety-critical effect of drowsy and fatigued driving. However, only 4% of all the respondents reported accidents due to fatigue and drowsiness at the wheel. Some of the main self-perceived reasons reported by them for their reduced alertness and increased sleepiness while driving were insufficient rest or sleep deprivation, monotonous road conditions and inactivity, and driving for long hours.

Table 3
Descriptive Statistics of duration of on-duty period.

Variable description	N	Minimum	Maximum	Mean	Std. Deviation
On duty working hours/day in last 5 years (in hours)	453	5	24	13.62	5.35
Duration of driving per day (in hours)	453	4	16	8.54	2.26
Number of working days in a week	453	2	7	6.42	0.95

Table 4
Descriptive statistics of categorical variables.

Description	Variable coding	Categories	Frequency/ number	Percent (%)
Age	Age	25 or below	49	10.82
		26–35	217	47.90
		36–45	140	30.91
		46–55	39	8.61
		56+	8	1.77
Education	edu	(School level) Grade 5	88	19.43
		(School level) up to Grade 8	202	44.59
		Metric or 10th grade	92	20.31
		(Pre-college level) 12th	71	15.67
Family responsibility/Sole earners	famresp	No	70	15.45
		Yes	383	84.55
Experience (years of holding truck driving license)	expyrs	0–5	65	14.30
		5–10	190	41.94
		10–15	121	26.71
		15 and above	77	16.99
Type of work-shift	wrkshft	Fixed/regular shift	162	35.76
		Irregular or rotating working hours	291	64.24
Most frequent driving time	wrktim	Daytime (8 am-post lunch)	162	35.76
		Evening (post lunch–8 pm)	92	20.31
		Night (8 pm–1 am)	107	23.62
		Late night (1 am–8 am)	24	5.30
		Any time	68	15.01
Purpose of breaks	brkfor	Meals only	191	42.16
		Rest only	14	3.09
		At destinations only	65	14.35
		Both at meals and destination	66	14.57
		All types	117	25.83
General interval of taking breaks	intbrk	1 h or less	72	15.89
		1–4 h	190	41.94
		4–5 h	113	24.94
		5–6 h	71	15.67
		6+ h	7	1.55
Duration of sleeping per day in hours	sleeph	less than 4 h	37	8.17
		4–6 h	126	27.81
		6–8 h	195	43.05
		8–10 h	84	18.54
		More than 10 h	11	2.43
Frequency of receiving tickets for violations	Penalty	Never	369	81.50
		Sometimes	70	15.50
		Often	14	3.10
Payment type	payondel	Fixed monthly salary (time based)	350	77.26
		On completion of work (on delivery)	84	18.54
		On basis of km driven (trip length)	19	4.19
Frequency of physical exercise	exercise	Never	418	92.27
		Sometimes (once or twice in a month)	29	6.40
		Very often or always	6	1.32
Frequency of alcohol consumption	drinking	Never	376	83.00
		Sometime (once or twice in a month)	46	10.15
		Often (more than two times a week)	31	6.84
Frequency of smoking per day	smoking	0	245	54.08
		1–5 times	113	24.94
		More than 5 times	95	20.97
Sufficient rest time available (self-reported)	sufresth	No	182	40.18
		Yes	271	59.82
Insufficient water intake (below 2 L/day)	insufwat	2 L or Above	157	34.66
		<2 L (insufficient water intake)	296	65.34
Is waiting in queues a monotonous and sleep-inducing task?	waiting	No	253	55.85
		Yes	200	44.15
Caffeine/tea intake per day	cafperd	No	114	25.17
		Yes	339	74.83
Using non-drive period as rest break	ndriv_rest	No	174	38.41
		Yes	279	61.59

4. Analysis and results

To achieve the desired objectives of the study, the following statistical analysis was performed. All the factors used in the questionnaire to test the effect of incentives on driving hours (listed in Table 5 and Appendix A) were found significantly correlated. Therefore, Principal Component Analysis (PCA) was used to reduce the number of independent variables into uncorrelated components. Secondly, to test the differences between drowsy and non-drowsy group of drivers as a result of incentives, Kruskal-Wallis test was performed with the factors extracted using PCA. Finally, to determine the predictors of drowsy driving among long-haul truck drivers a logistic regression model was developed. The study takes into account the driver demographics, work-rest patterns, lifestyle and economic incentives as explanatory variables (as discussed in Table 2 in the literature, also confer Table 6 and Appendix A) and driver's history of falling asleep at the wheel as the dependent variable. All the analysis was performed using IBM SPSS Statistics V22.

4.1. Principal component analysis

PCA is a method of orthogonal linear transformation which reduces possible correlated variables into a smaller number of variables called principal components (Maji, Velaga, & Urie, 2018; Sullman et al., 2002; Ting, Hwang, Doong, & Jeng, 2008). The initial PCA with oblimin rotation resulted in two weakly correlated factors (Pearson's correlation coefficient 'r' < 0.4). Therefore, the final PCA was performed with varimax rotation to obtain uncorrelated factors. The factor analysis explained 54.51% of the variance in total. Table 5 summarizes the results of the factor analysis. The analysis resulted in two components with eigen values >1, and the scree plot results also supported retaining the two-factor solution (confer Fig. 2). The items with very low factor loadings (<0.1) were suppressed in the results. The items 1–5 loaded heavily on the first factor while items 6–9 loaded heavily on the second factor and item 10 moderately loaded on the second factor.

The first factor contained questions enquiring about the willingness of a truck driver to earn additional monetary benefits by compromising his rest requirements (willingness to avoid breaks). Hence, motivating him to undertake long trips, short time-saving routes or night shifts are associated with drowsy driving risks. Thus, the factor was named *willingness to earn extra payments* (WEP).

The second factor contained questions representing the involvement of the truck driver in additional works for monetary rewards. Therefore, these items were associated with motivation to drive longer hours and compromise rest in the current driving task; this factor was named *incentives associated with current driving (ICD)*.

4.2. Kruskal-Wallis test

Kruskal-Wallis is a well-known non-parametric test alternative to ANOVA (Philip et al., 2002; Sabahiah et al., 2017). Keeping in line with one of the stated objectives, to examine the significant differences between the groups of drowsy and non-drowsy drivers based on the opportunities of monetary incentives, Kruskal-Wallis test was used. The test was performed with the two factors extracted using PCA. The test with the factor willingness to earn extra payments (WEP) revealed a statistically significant difference between the drivers who often fall asleep while driving (n = 90) and those who do not (n = 363), χ^2 (1, n = 453) = 4.46, p < 0.05. Similarly, the test with the other factor incentives associated with current driving (ICD) also revealed a statistically significant difference between the two groups, χ^2 (1, n = 453) = 13.24, p < 0.001. This indicates a significant association between the sleepy drivers and the role of incentives in compromising their rest breaks to work longer hours. Further, to quantitatively determine the role of different factors in causing driver sleepiness at the wheel, logistic regression was used.

Table 5
Factor analysis representing various payment-based motivations to drowsy driving (also confer Appendix A).

Item No.	Description of payment related motivations	Frequency of 'yes' (N = 453)	Percent (%)	Component	
				Willingness to earn extra payments (WEP)	Incentives and current driving (ICD)
1.	Willingness to work overtime (or lengthy trips)	124	27.37	0.701	0.137
2.	Willingness to prefer night shift for extra payment	184	40.62	**0.616**	<0.1
3.	Willingness to take short uncomfortable routes during a lengthy trip to save fuel	168	37.09	**0.724**	0.224
4.	Willingness to over speed	105	23.18	**0.765**	0.245
5.	Willingness to avoid rest breaks in lengthy trips	110	24.28	**0.746**	0.239
6.	Additional payment for non-driving works	50	11.04	0.145	**0.796**
7.	Reward for timed deliveries	54	11.92	0.157	**0.638**
8.	Penalty for late arrivals	98	21.63	0.184	**0.699**
9.	Involvement in non-driving works	53	11.70	0.132	**0.823**
10.	Time pressure	113	24.94	0.323	**0.558**
Eigen values (after rotation)				4.032	1.419
% Variance explained				40.32	14.19

Note: Factor loadings highlighted in boldface represent the factors contributing to each component WEP or ICD.

Table 6
Logistic regression of factors associated with driver falling asleep while driving among Indian truck drivers (Dependent Variable: experiences of falling asleep at the wheel in last 5 years; 0 = No (363), 1 = Yes (N = 90)).

S. No.	Description	Categories	B	S.E.	Wald	p-value	Odds Ratio
1.	Age	25 or below			7.711		*Ref.*
		26–35	−1.209	0.624	3.757	0.053	**0.299***
		36–45	−1.249	0.683	3.342	0.068	**0.287***
		46–55	−1.488	0.860	2.996	0.083	**0.226***
		56+	1.005	1.225	0.672	0.412	2.731
2.	Highest education level completed	(Primary school level) Grade 5			4.466	0.215	*Ref.*
		School up to Grade 8	0.440	0.480	0.838	0.360	1.552
		Metric or 10th grade	0.731	0.483	2.293	0.130	2.077
		12th or above	−0.350	0.590	0.351	0.554	0.705
3.	Professional truck driving experience (in years)	0–5			3.159		*Ref.*
		5–10	−0.161	0.567	0.081	0.776	0.851
		10–15	0.533	0.623	0.731	0.393	1.704
		15 and above	0.397	0.708	0.314	0.575	1.487
4.	Family responsibility		0.504	0.509	0.983	0.322	1.655
5.	Irregular type of work shift w.r.t regular or fixed work shift		0.059	0.397	0.022	0.882	1.061
6.	Number of total working hours per day		−0.015	0.034	0.182	0.670	0.985
7.	Number of working days per week		−0.342	0.195	3.089	0.079	**0.710***
8.	Most frequent driving time of the day	Daytime (8 am-lunch)			5.433		*Ref.*
		Evening (post lunch–8 pm)	−0.184	0.496	0.138	0.711	0.832
		Night (8 pm–1 am)	−0.365	0.486	0.563	0.453	0.694
		Early morning (1 am–8 am)	0.229	0.703	0.106	0.745	1.257
		Any time	−1.132	0.524	4.667	0.031	**0.322****
9.	Number of driving hours per day		0.421	0.083	25.714	0.000	**1.523*****
10.	Types of in between breaks	Only for meals			12.449	0.014	*Ref.*
		Only for rest	0.612	1.201	0.259	0.611	1.843
		Only after reaching destination	−0.410	0.547	0.561	0.454	0.664
		Both at meals and destination	−0.540	0.562	0.923	0.337	0.583
		All types	−1.645	0.496	10.985	0.001	**0.193*****
11.	Continuous driving hours without any break (15 min or more) in general	Up to 1 h			8.641	0.071	*Ref.*
		Up to 4 h	1.231	0.624	3.888	0.049	**3.425****
		4–5 h	1.043	0.688	2.298	0.130	2.839
		5–6 h	1.126	0.733	2.358	0.125	3.083
		6+ h	3.008	1.072	7.872	0.005	**20.24*****
12.	Average number of hours slept per day in general	<4 h			10.116	0.039	*Ref.*
		4–6 h	−0.622	0.574	1.175	0.278	0.537
		6–8 h	−1.571	0.605	6.746	0.009	**0.208*****
		8–10 h	−0.771	0.652	1.396	0.237	0.463
		More than 10 h	−1.662	1.107	2.256	0.133	0.190
13.	Using non-drive period as rest break		0.184	0.376	0.239	0.625	1.202
14.	Rest time provided by owner is sufficient to alleviate stress		−0.317	0.384	0.682	0.409	0.728
15.	Waiting in queues a monotonous and sleep inducing task		0.304	0.351	0.751	0.386	1.355
16.	Caffeine/tea intake per day		1.042	0.540	3.722	0.054	**2.835***
17.	Frequency of alcohol consumption	Never			1.538	0.464	*Ref.*
		Sometimes	0.229	0.533	0.184	0.668	1.257
		Often	0.775	0.631	1.507	0.220	2.170
18.	Intake of cig/tobacco per day	0			6.193	0.045	*Ref.*
		1–5 times	0.882	0.380	5.389	0.020	**2.415****
		More than 5 times	0.119	0.465	0.065	0.798	1.126
19.	Physical exercise or activities	Never			0.700	0.705	*Ref.*
		Sometimes (once or twice in a month)	−0.231	0.564	0.168	0.682	0.794
		Very often or always	0.873	1.198	0.531	0.466	2.393
20.	Insufficient water intake (below 2 L/day)		1.650	0.502	10.820	0.001	**5.207*****
21.	Body Mass Index (BMI)		−0.008	0.038	0.047	0.829	0.992
22.	Frequency of getting tickets for violations	Never			8.247	0.016	*Ref.*
		Sometimes (once or twice in a week)	0.885	0.388	5.222	0.022	**2.424****
		Very often or always	1.760	0.878	4.016	0.045	**5.810****
23.	Type of salary	Fixed monthly salary			0.322	0.851	*Ref.*
		On completion of work (on delivery)	−0.212	0.427	0.247	0.619	0.809
		On the basis of km driven	0.132	0.708	0.035	0.853	1.141
24.	Incentives and current driving (ICD)		0.455	0.163	7.805	0.005	**1.577*****
25.	Intercept		−4.962	2.014	6.067	0.014	**0.007**

Ref.: 'Reference category'; '*' $p < 0.1$; '**' $p < 0.05$; '***' $p < 0.01$.
Overall model χ^2 (48, N = 453) = 150.566, $p < 0.001$; Hosmer and Lemeshow test χ^2 (8) = 6.322, $p = 0.611$; Nagelkerke $r^2 = 44.8\%$ and Cox and Snell $r^2 = 28.3\%$.
Note: Boldface indicates Odds Ratio of statistically significant (at the 90% credible interval) variable.

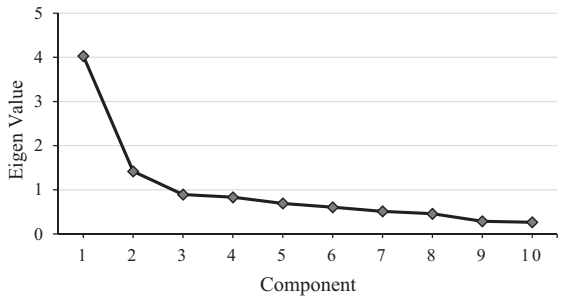

Fig. 2. Scree Plot showing two major factors (Eigen Value >1) resulting from factor analysis.

4.3. Logistic regression

Logistic regression has been used to find the significant contributors of drowsy driving and sleep-related accident risk (e.g. Häkkänen & Summala, 2001; Meng et al., 2015; Papadakaki et al., 2008; Tzamalouka et al., 2005). In this study, the response to self-reported instances of drowsy driving in the past five years (lapses or incidences of nodding off even for a short while) was taken as the dichotomous dependent variable. Based on findings from the literature review (confer Table 2), the model included the following explanatory variables:

Driver demographics: age, experience of professional truck driving, education level, family responsibility which might affect driver capability to manage fatigue while driving.

Driver lifestyle: work-rest duration, interval of intermediate breaks per trip, time of the drive, sleeping duration, all routine habits of the driver related with his sleep and fatigue while driving for example, consumption of caffeine, alcohol, tobacco or water.

Driver payment motivations: involvement in non-driving works, type of payment (flat rate on delivery or trip length based). The two derived factors Willingness to earn extra payments (WEP) and incentives and current driving (ICD), were found highly correlated (correlation coefficient >0.7), therefore to avoid multicollinearity issues only one of the factors can be considered in the model. Further, chi-square test of independence showed that ICD was having higher association compared to WEP with the dependent binary variable of instances of falling asleep while driving (χ^2 (5, n = 453) = 28.38, p < 0.001). Hence, ICD was taken as one of the explanatory variables in the model.

The model was able to classify 85.2% of cases correctly keeping 95% confidence level. As shown in Table 6, categories of age (i.e., younger and middle-aged drivers), working days in a week, total driving hours, the interval of breaks between continuous driving, sleep duration, consumption of caffeine, tobacco or cigarettes and insufficient water, history of receiving a penalty for traffic rules violation and payment incentives in current driving (ICD) were found significantly associated with drowsy driving instances among long-haul truck drivers. None of the other factors was statistically significant. The values of pseudo R-square (Cox & Snell r^2 = 0.283 and Nagelkerke r^2 = 0.448), suggest that the model was able to explain 28.3% to 44.8% of the variability in the dependent variable. Though the R-square values are comparable with the existing literature in this field (Bunn, Slavova, Struttmann, & Browning, 2005; Tzamalouka et al., 2005; Williamson & Friswell, 2013 etc.), further larger sample size might have explained the variability in dependent variable to a greater extent.

5. Discussion

The results show that driver lifestyle and financial factors play a significant role in driver drowsiness while driving. They are further discussed below.

5.1. Influence of driver background factors

Drivers between 25–36, 36–45 and 46–55 years were found at 70%, 71% and 77% less risk of drowsy driving respectively, compared to young and novice drivers below 25 years. This might be explained by the lesser experience of young drivers to curb the effects of sleepiness compared to older drivers (Smith et al., 2009). Another possibility could be that young drivers preferred to get involved in long-duration trips due to more eagerness to earn money (Campos Monteiro et al., 2015). Duke et al. (2010) also reported similar findings that drowsiness symptoms show a u-shaped curve with driver's age. Most of the middle-aged drivers were married therefore associated responsibility of family or partner might have encouraged them to drive cautiously. However, the variable family responsibility in the proposed hypothesis was found insignificant in the current study. Driving experience and driver education status did not make a significant contribution in the model contrary to the findings in some of the previous studies (Barr et al., 2005; Sullman et al., 2002). The possible reason for this might be that the current sample did not cover a range of variability among these variables for comparison. However, Zhang et al. (2016) have also reported education and experience as insignificant variables in their study.

5.2. Influence of work-rest pattern

The truck drivers in the current sample spent almost 14-hours a day on duty and most of the time was spent in driving. Moreover, the drivers reported being on duty for the entire week without any holidays, thereby not allowing them sufficient time to rest. Therefore, the drivers violated the 'in-between rest breaks' and 'minimum rest duration' as stated in HOS rules (confer Table 1). As per model results, the additional working days in a week were associated with decrease in odds of sleepiness (confer Table 6). However, according to the model results, each additional hour of driving increased the odds of sleepy lapses at the wheel by 1.5 times (Fig. 3).

Similarly, Arnold et al. (1997) and Knutsson et al. (2002) have also reported that longer driving hours increase the probability of sleepy lapses while driving. Therefore, it can be implied that the odds of driver drowsiness are more significantly affected by duration of driving than the number of working days. Interestingly, the results also showed that as the continuous hours of driving without taking any breaks increased beyond 6-h, the odds of sleepiness at the wheel increased heavily. This might be a result of 'accumulated fatigue' among the drivers due to long and continuous hours of driving (May & Baldwin, 2009). According to previous studies, driving during the night time and after lunch have been significantly associated with higher decrement in driver alertness during a day (Gastaldi, Rossi, & Gecchele, 2014; Sagaspe et al., 2008; Thiffault & Bergeron, 2003; Zhang et al., 2014, 2016). However, in the current study, the time of drive was enquired from the drivers on the basis of the start time of their shift. This might be the reason that the 'time of drive' did not contribute significantly to the model.

In previous studies, sleeping duration less than seven hours has been associated with increased cases of drowsy driving crashes among truck drivers (Tzamalouka et al., 2005). Drivers who were partially sleep deprived (sleeping less than 4-h daily) were found to be at 4.8 folds higher risk of falling asleep at the wheel as compared to the sufficiently sleeping (6–8 h) drivers. Similarly, Maia et al. (2013) also found that as compared to the drivers taking appropriate sleep of 7 h, the drivers taking short (6 h) and very short (<5 h) duration of sleep were at 2 and 3.8 times higher risk of drowsy driving respectively. Therefore, the proposed hypothesis regarding the negative effects of violation of HOS rules and extended driving hours was found to be true.

5.3. Influence of driver lifestyle

The results of the regression analysis emphasized the association of higher intake of caffeinated beverages while driving (minimum three times a day) with increased odds of sleepiness among Indian truck drivers. Similarly, the higher intake of tobacco or cigarettes while driving (smoking about 1–5 times a day) compared to non-smokers was associated with 2.4 times increased sleepiness among the drivers. The drivers might have increased the consumption of tobacco and caffeine as they recognized any decrement in their alertness while driving (Howard et al., 2014; Johnson et al., 2015; Watling et al., 2014). Contrary to the results obtained by Du, Zhao, Zhang, and Rong (2016), consumption of alcohol was found insignificant in the analysis. This might be owed to underreporting of such events by the drivers, due to public shyness to disclose their drinking habits during a face-to-face interview survey. Majority of the drivers (93%) did not involve in any physical exercise, this might be the reason that the model could not deduce any effect of exercise on driver alertness. Apart from caffeine intake and smoking as sleepiness countermeasures, consumption of water is also one of the effective countermeasures to fight fatigue and sleepiness (McKernon, 2008; Pylkkönen et al., 2015). Therefore, insufficient consumption of water per day (minimum of 2 L/day for fulfilling metabolic needs) might also be responsible for increased odds of sleepiness while driving in the current study (confer Table 6). Thus, the proposed hypothesis was found partially true. A higher urge for caffeine and smoking indicate increased sleepiness while sufficient water intake can be used as a way to maintain alertness while driving.

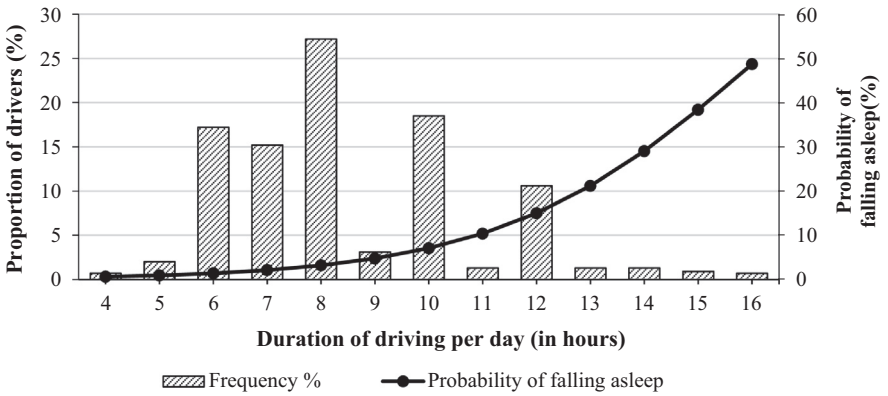

Fig. 3. Probability of falling asleep with duration of driving per day.

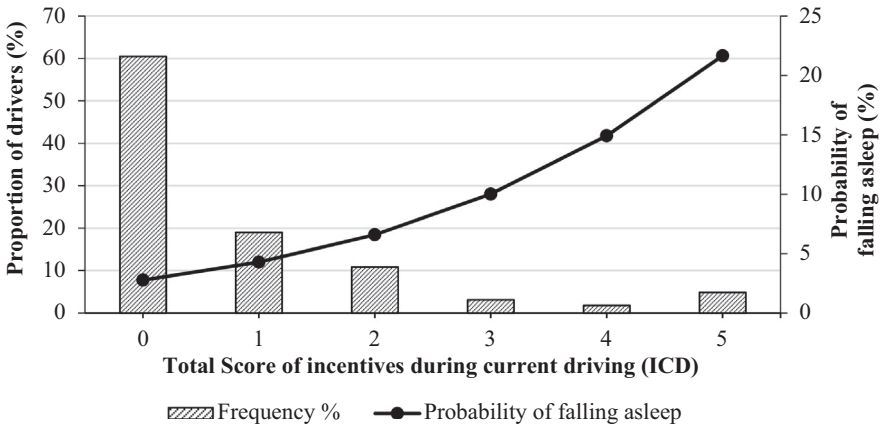

Fig. 4. Probability of falling asleep at the wheel while driving with incentives during current driving (ICD).

5.4. Influence of payment and incentives

Thompson et al. (2015) have found that drivers who were paid 'per km' were involved in longer driving periods without any rest breaks or sleeping and also involved in a higher number of crashes compared to drivers who were paid 'flat rate' or 'per trip'. Also, in the previous studies, opportunities for the extra monetary benefits for non-driving works have been associated with longer driving hours and driver sleepiness (Williamson & Friswell, 2013). The drivers were asked multiple questions in the survey regarding the influence of the type of payment and additional incentives motivating their extended working hours (confer Table 5). As shown in the regression results in Table 6, the odds of sleepiness among drivers increased by 1.5 times for drivers scoring high on the factor '*Incentives in current driving (ICD)*' (Fig. 4). Therefore, it may also be concluded that incentives for early or on-time deliveries with the aim of increasing productivity might have motivated the truckers to drive longer hours. In the current sample, a very large proportion of truck drivers (85%) had associated financial responsibilities of their families or they were 'the sole earners' which might be the reason for their inclination towards earning incentives. Moreover, the majority of drivers were less educated (64% below 10th standard) to understand the risks of avoiding proper sleep and rest. This is also indicated by their involvement in frequent violations varying from 'sometimes' to 'often' with increased odds of sleepiness by 2.4–5.8 times respectively compared to non-violators (Table 6).

5.5. Methodological limitations

A possible limitation of the study is the comparatively low variance in certain variables (such as education) in the current data to draw a comparison between different drivers. The survey was interview based and relied completely on driver's self-perception about fatigue and other questions. Therefore, the sample can be response biased due to comparatively low participation rate. A major challenge in collecting large sample size in such studies is to convince reluctant truck drivers to stop and participate in the survey or stay till the completion of survey. The sample size considered in the current study may not be representative of the entire population of truck drivers. Future studies can focus on these factors considering a further large sample size. Also, Asian Institute of Transport Development (AITD) (2000) states that power steering helps in reducing the driver fatigue and the driver response time compared to manual steering. The effect of such mechanical factors can also be covered in the future research. In case of long-haul truck drivers, the drivers are involved in long journeys and spend days or weeks away from their families. Therefore, further the effect of sexual lifestyle of such drivers on driving performance is also an interesting field to explore in future research. In a developing country such as India, there is a financial dependence of family members on the drivers as 'the sole earners' of the family particularly, in case of low educated and unemployed families. Such family responsibilities on the drivers may also motivate them to indulge in overtime and violation of 'hours of service' rules for monetary incentives. Thus, the role of family responsibility among drivers can indirectly serve as a potential challenge to traffic safety in developing countries.

6. Conclusion

The rate of violations of HOS rules and holding license without mandatory educational qualification show the lack of stringent enforcement actions by the authorities. As a result of the violations of HOS rules, the drivers are found to be involved in incidents of falling asleep at the wheel. The results of the study emphasize the negative effects of payment incentives to driver safety and fatigue management. This study shows that the payment system of freight employers and companies is mostly productivity driven (22% receive pay with a task or trip completion and majority is interested in earning incentives). The non-driving tasks like loading/unloading or waiting in queues are not counted for payments for most of

Table A1
Description of various payment related motivations influencing driving behavior.

Question in the questionnaire	Payment related motivation	'Yes' (N = 453)
1. Are you being additionally paid for any non-driving works such as loading, unloading, waiting in queues etc.?	Additional payment for non-driving works	50
2. Do you receive any *financial reward* for early or on time arrivals?	Reward for timed deliveries	54
3. Do you receive any *financial penalty* for late arrival?	Penalty for late arrivals	98
4. Do you get involved in non-driving works (like loading-unloading) when you are paid for it?	Involvement in non-driving works	53
5. Is there any pressure of timed delivery of goods/material carried by you that affects your job (in turn your salary) or driving actions?	Time pressure	113
6. Do you believe that payment *incentives for overtime* motivate you to take lengthy trips i.e. *drive more hours or more km*?	Willingness for overtime (or lengthy trips)	124
7. Will you prefer to take night shift (8 pm–8 am) over day shift for any additional payment?	Willingness to prefer night shift for extra payment	184
8. Does intention of saving fuel (hence saving money) motivate your driving actions like preferring short uncomfortable routes in a lengthy trip?	Willingness to take short uncomfortable routes during a lengthy trip to save fuel	168
9. If incentives are associated with specified timings and schedules in your driving, then does it motivate you to *violate speeding and other traffic* regulations?	Willingness to over speed	105
10. If incentives are associated with specified timings and schedules in your driving, then does it motivate you to drive more hours continuous *or avoid breaks in long trips*?	Willingness to avoid rest breaks in lengthy trips	110

the long-haul truck drivers according to the current survey. However, being time-bounded for deliveries, any likelihood of financial rewards or penalties has been certainly found to influence their duration of work and rest. This influences their fatigue risk management while driving as they compromise their essential resting hours for additional productivity. According to regression results, the drivers receiving incentives in current driving faced 1.58 times higher odds of falling asleep while driving, which proves the novelty of the concept of economic motivations proposed in this study. The drivers who are able to manage their fatigue and sleepiness by avoiding additional works for incentives, and taking adequate rest and breaks are expected to be comparatively safer towards sleepy driving risks. Therefore, the freight companies shall be encouraged to reduce the pressure of incentives-based driving on the long-haul freight transport drivers. Investigating further the role of payment incentives in motivating the drivers to engage in risky and unsafe driving practices, committing traffic violations under pressure of timeliness in their trips would be a useful topic for future research.

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Appendix A

See Table A1.

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2018.10.028.

References

Adams-guppy, J., & Guppy, A. (2003). Truck driver fatigue risk assessment and management: A multinational survey. *Ergonomics, 46*(8), 763–779. https://doi.org/10.1080/0014013021000056980.

Aidman, E., Chadunow, C., Johnson, K., & Reece, J. (2015). Real-time driver drowsiness feedback improves driver alertness and self-reported driving performance. *Accident Analysis and Prevention, 81*, 8–13. https://doi.org/10.1016/j.aap.2015.03.041.

Al-Houqani, M., Eid, H. O., & Abu-Zidan, F. M. (2013). Sleep-related collisions in United Arab Emirates. *Accident Analysis and Prevention, 50*, 1052–1055. https://doi.org/10.1016/j.aap.2012.08.010.

Alonso, F., Esteban, C., Useche, S. A., & De Cózar, E. L. (2016). Prevalence of physical and mental fatigue symptoms on Spanish drivers and its incidence on driving safety. *Advances in Psychology and Neuroscience, 1*(2), 10–18. https://doi.org/10.11648/j.apn.20160102.12.

Anund, A., Kecklund, G., & Åkerstedt, T. (2011). *Sleepiness, crashes and the effectiveness of countermeasures*. Swedish National Road and Transport Research Institute (VTI).

Arnold, P. K., Hartley, L. R., Corry, A., Hochstadt, D., Penna, F., & Feyer, A. M. (1997). Hours of work, and perceptions of fatigue among truck drivers. *Accident Analysis and Prevention, 29*(4 SPEC. ISS.), 471–477. https://doi.org/10.1016/S0001-4575(97)00026-2.

Asian Institute of Transport Development (AITD) (2000). Technology change: Slow and unsteady. In H. Bhaya, K. L. Thapar, S. R. Hashim, Y. K. Alagh, D. Mohan, & S. Raghavan (Eds.), *Indian trucking* (pp. 44–52). Asian Institute of Transport Development.

Asian Institute of Transport Development (AITD) (2015). *Study on trucking operations in India – Problems & potential*. Asian Institute of Transport Development (AITD) & Central Institute of Road Transport.
Barr, L. C., Yang, C. Y. D., Hanowski, R. J., & Olson, R. (2005). Assessment of driver fatigue, distraction, and performance in a naturalistic setting. *Transportation Research Record, 1937*, 51–60. https://doi.org/10.3141/1937-08.
Bener, A., Crundall, D., Haigney, D., Bensiali, A. K., & Al-Falasi, A. S. (2007). Driving behaviour, lapses, errors and violations on the road: United Arab Emirates study. *Advances in Transportation Studies, 12*, 5–14.
Blanco, M., Hanowski, R. J., Olson, R. L., Morgan, J. F., Soccolich, S. A., Wu, S.-C., & Guo, F. (2011). The impact of driving, non-driving work, and rest breaks on driving performance in commercial motor vehicle operations. http://doi.org/10.1037/e625382011-001.
Blower, D., Green, P., & Matteson, A. (2010). Condition of trucks and truck crash involvement. *Transportation Research Record: Journal of the Transportation Research Board, 2194*(2194), 21–28. https://doi.org/10.3141/2194-03.
British Columbia Truckers Association (BCTA) (2013). International trucking reference: Roads, rules, and drivers.
Brower, K. J. (2009). Alcohol's effects on sleep in alcoholics. *Alcohol Research & Health, 25*(2), 110–125.
Bunn, T. L., Slavova, S., Struttmann, T. W., & Browning, S. R. (2005). Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries. *Accident Analysis and Prevention, 37*(5), 862–869. https://doi.org/10.1016/j.aap.2005.04.004.
Campos Monteiro, D. L., Peñaloza, V., Pinto, F. R., Denegri Coria, M. del C., & Orellana Calderón, L. M. (2015). Attitudes towards money and motivational orientation to work in Brazilian young workers. *Contaduría y Administración, 60*(1), 11–30. https://doi.org/10.1016/S0186-1042(15)72145-5.
Cantor, D. E., Corsi, T. M., Grimm, C. M., & Ozpolat, K. (2010). A driver focused truck crash prediction model. *Transportation Research Part E: Logistics and Transportation Review, 46*(5), 683–692. https://doi.org/10.1016/j.tre.2009.08.011.
Castillo-Manzano, J. I., Castro-Nuño, M., & Fageda, X. (2016). Exploring the relationship between truck load capacity and traffic accidents in the European Union. *Transportation Research Part E: Logistics and Transportation Review, 88*, 94–109. https://doi.org/10.1016/j.tre.2016.02.003.
Chen, G. X., Fang, Y., Guo, F., & Hanowski, R. J. (2016). The influence of daily sleep patterns of commercial truck drivers on driving performance. *Accident Analysis and Prevention, 91*, 55–63. https://doi.org/10.1016/j.aap.2016.02.027.
Department of Economic and Social Affairs, U. (2017). Household size and composition around the world 2017-data booklet (ST/ESA/SER.A/405). http://doi.org/10.3390/atmos6091362.
Di Milia, L., Smolensky, M. H., Costa, G., Howarth, H. D., Ohayon, M. M., & Philip, P. (2011). Demographic factors, fatigue, and driving accidents: An examination of the published literature. *Accident Analysis and Prevention, 43*(2), 516–532. https://doi.org/10.1016/j.aap.2009.12.018.
Dogan, E., Steg, L., & Delhomme, P. (2011). The influence of multiple goals on driving behavior: The case of safety, time saving, and fuel saving. *Accident Analysis and Prevention, 43*(5), 1635–1643. https://doi.org/10.1016/j.aap.2011.03.002.
Du, H., Zhao, X., Zhang, G., & Rong, J. (2016). Effects of alcohol and fatigue on driving performance in different roadway geometries. *Transportation Research Record, 88–96*. https://doi.org/10.3141/2584-11.
Duke, J., Guest, M., & Boggess, M. (2010). Age-related safety in professional heavy vehicle drivers: A literature review. *Accident Analysis and Prevention, 42*(2), 364–371. https://doi.org/10.1016/j.aap.2009.09.026.
Ericsson, E., Larsson, H., & Brundell-Freij, K. (2006). Optimizing route choice for lowest fuel consumption – Potential effects of a new driver support tool. *Transportation Research Part C: Emerging Technologies, 14*(6), 369–383. https://doi.org/10.1016/j.trc.2006.10.001.
Federal Motor Carrier Safety Administration (2015). Interstate truck driver's guide to hours of service. Retrieved from http://www.fmcsa.dot.gov/rules-regulations/truck/driver/hos/fmcsa-guide-to-hos.pdf.
Gastaldi, M., Rossi, R., & Gecchele, G. (2014). Effects of driver task-related fatigue on driving performance. *Procedia – Social and Behavioral Sciences, 111*, 955–964. https://doi.org/10.1016/j.sbspro.2014.01.130.
Girotto, E., de Andrade, S. M., Gonzalez, A. D., & Mesas, A. E. (2016). Professional experience and traffic accidents/near-miss accidents among truck drivers. *Accident Analysis and Prevention, 95*, 299–304. https://doi.org/10.1016/j.aap.2016.07.004.
Government of India, & Ministry of Labour and Employment (1961). The motor transport workers act, 1961 (1988). India.
Häkkänen, H., & Summala, H. (2001). Fatal traffic accidents among trailer truck drivers and accident causes as viewed by other truck drivers. *Accident Analysis and Prevention, 33*(2), 187–196. https://doi.org/10.1016/S0001-4575(00)00030-0.
Highway Traffic Safety Administration, N., & Department of Transportation, U. (2015). TRAFFIC SAFETY FACTS early estimate of motor vehicle traffic fatalities in 2015, (July), 2013–2016.
Howard, M. E., Jackson, M. L., Berlowitz, D., O'Donoghue, F., Swann, P., Westlake, J., ... Pierce, R. J. (2014). Specific sleepiness symptoms are indicators of performance impairment during sleep deprivation. *Accident Analysis and Prevention, 62*, 1–8. https://doi.org/10.1016/j.aap.2013.09.003.
Indian Institute of Management Calcutta (2009). Operational efficiency of national highways for freight transportation in India. Delhi, India. Retrieved from http://www.tcil.com/tcil/pdf/tci&iimstudyreport.pdf.
Johns, M. W. (2000). A sleep physiologist's view of the drowsy driver. *Transportation Research Part F, 3*(4), 241–249. https://doi.org/10.1016/S1369-8478(01)00008-0.
Johnson, K. D., Patel, S. R., Baur, D. M., Edens, E., Sherry, P., Malhotra, A., & Kales, S. N. (2015). Association of sleep habits with accidents and near misses in United States transportation operators. *Journal of Occupational and Environmental Medicine, 33*(4), 395–401. https://doi.org/10.1038/nbt.3121.ChIP-nexus.
Kanazawa, H., Suzuki, M., Onoda, T., & Yokozawa, N. (2006). Excess workload and sleep-related symptoms among commercial long-haul truck drivers. *Sleep and Biological Rhythms, 4*(2), 121–128. https://doi.org/10.1111/j.1479-8425.2006.00218.x.
Knutsson, A., Westerholm, P., Theorell, T., Alfredsson, L., Kecklund, G., Åkerstedt, T., ... Kecklund, G. (2002). Sleep disturbances, work stress and work hours: A cross-sectional study. *Journal of Psychosomatic Research, 53*(3), 741–748. https://doi.org/10.1016/S0022-3999(02)00333-1.
Lauper, E., Moser, S., Fischer, M., Matthies, E., & Kaufmann-Hayoz, R. (2015). Psychological predictors of eco-driving: A longitudinal study. *Transportation Research Part F: Traffic Psychology and Behaviour, 33*, 27–37. https://doi.org/10.1016/j.trf.2015.06.005.
Lin, T., Jovanis, P. P., & Yang, C. (1984). Modeling the safety of truck driver service hours using time-dependent logistic regression II.
Maia, Q., Grandner, M. A., Findley, J., & Gurubhagavatula, I. (2013). Short and long sleep duration and risk of drowsy driving and the role of subjective sleep insufficiency. *Accident Analysis and Prevention, 59*, 618–622. https://doi.org/10.1016/j.aap.2013.07.028.
Maji, A., Velaga, N. R., & Urie, U. (2018). Hierarchical clustering analysis framework of mutually exclusive crash causation parameters for regional road safety strategies. *International Journal of Injury Control and Safety Promotion, 25*(3), 257–271. https://doi.org/10.1080/17457300.2017.1416485.
Matthews, R. W., Ferguson, S. A., Zhou, X., Kosmadopoulos, A., Kennaway, D. J., & Roach, G. D. (2012). Simulated driving under the influence of extended wake, time of day and sleep restriction. *Accident Analysis and Prevention, 45*(SUPPL.), 55–61. https://doi.org/10.1016/j.aap.2011.09.027.
May, J. F., & Baldwin, C. L. (2009). Driver fatigue: The importance of identifying causal factors of fatigue when considering detection and countermeasure technologies. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*(3), 218–224. https://doi.org/10.1016/j.trf.2008.11.005.
McCartt, A. T., Ribner, S. A., Pack, A. I., & Hammer, M. C. (1996). The scope and nature of the drowsy driving problem in New York state. *Accident Analysis and Prevention, 28*(4), 511–517. https://doi.org/10.1016/0001-4575(96)00021-8.
McCartt, A. T., Rohrbaugh, J. W., Hammer, M. C., & Fuller, S. Z. (2000). Factors associated with falling asleep at the wheel among long-distance truck drivers. *Accident Analysis and Prevention, 32*(4), 493–504. https://doi.org/10.1016/S0001-4575(99)00067-6.
McKernon, S. (2008). A literature review on driver fatigue among drivers in the general public. NZ Transport Agency research report 342. Retrieved from http://www.nzta.govt.nz.
Medvedev, D., Shome, S., Seth, S., & Misra, J. (2014). *India development update*. The World Bank Group. Macroeconomics and Fiscal Management.
Meng, F., Li, S., Cao, L., Li, M., Peng, Q., Wang, C., & Zhang, W. (2015). Driving fatigue in professional drivers: A survey of truck and taxi drivers. *Traffic Injury Prevention, 16*(5), 474–483. https://doi.org/10.1080/15389588.2014.973945.

Mills, P. J., Kim, J. H., Bardwell, W., Hong, S., & Dimsdale, J. E. (2008). Predictors of fatigue in obstructive sleep apnea. *Sleep and Breathing, 12*(4), 397–399. https://doi.org/10.1007/s11325-008-0192-8.
Ministry of Labour & Employment (2008). Report on the working of the motor transport workers act, 1961 for the year 2008.
Morrow, P. C., & Crum, M. R. (2004). Antecedents of fatigue, close calls, and crashes among commercial motor-vehicle drivers. *Journal of Safety Research, 35*(1), 59–69. https://doi.org/10.1016/j.jsr.2003.07.004.
National Crime Records Bureau (2015). Accidental deaths & suicides in India, 2015. Retrieved from http://ncrb.gov.in.
National Road Safety Strategy (2011). Australian Transport Council. Retrieved from http://roadsafety.gov.au/nrss/files/NRSS_2011_2020.pdf.
Newnam, S., Mamo, W. G., & Tulu, G. S. (2014). Exploring differences in driving behaviour across age and years of education of taxi drivers in Addis Ababa, Ethiopia. *Safety Science, 68*, 1–5. https://doi.org/10.1016/j.ssci.2014.02.012.
Nordbakke, S., & Sagberg, F. (2007). Sleepy at the wheel: Knowledge, symptoms and behaviour among car drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 10*(1), 1–10. https://doi.org/10.1016/j.trf.2006.03.003.
Otmani, S., Roge, J., & Muzet, A. (2005). Sleepiness in professional drivers: Effect of age and time of day. *Accident Analysis and Prevention, 37*(5), 930–937. https://doi.org/10.1016/j.aap.2005.04.011.
Papadakaki, M., Kontogiannis, T., Tzamalouka, G., Darviri, C., & Chliaoutakis, J. (2008). Exploring the effects of lifestyle, sleep factors and driving behaviors on sleep-related road risk: A study of Greek drivers. *Accident Analysis and Prevention, 40*(6), 2029–2036. https://doi.org/10.1016/j.aap.2008.08.019.
Pérez-Chada, D., Videla, A. J., O'Flaherty, M. E., Palermo, P., Meoni, J., Sarchi, M. I., ... Sarchi, M. I. (2005). Sleep habits and accident risk among truck drivers: A cross-sectional study in Argentina. *Sleep, 28*(9), 1103–1108. https://doi.org/10.1016/S8756-3452(08)70700-X.
Philip, P., Taillard, J., Léger, D., Diefenbach, K., Akerstedt, T., Bioulac, B., & Guilleminault, C. (2002). Work and rest sleep schedules of 227 European truck drivers. *Sleep Medicine, 3*(6), 507–511. https://doi.org/10.1016/S1389-9457(02)00138-7.
Phillips, R. O. (2015). A review of definitions of fatigue – And a step towards a whole definition. *Transportation Research Part F: Traffic Psychology and Behaviour, 29*, 48–56. https://doi.org/10.1016/j.trf.2015.01.003.
Phillips, R. O., Kecklund, G., Anund, A., & Sallinen, M. (2017). Fatigue in transport: A review of exposure, risks, checks and controls. *Transport Reviews, 37*(6), 742–766. https://doi.org/10.1080/01441647.2017.1349844.
Pylkkönen, M., Sihvola, M., Hyvärinen, H. K., Puttonen, S., Hublin, C., & Sallinen, M. (2015). Sleepiness, sleep, and use of sleepiness countermeasures in shift-working long-haul truck drivers. *Accident Analysis and Prevention, 80*, 201–210. https://doi.org/10.1016/j.aap.2015.03.031.
Raghuram, G. (2015). An overview of the trucking sector in India: Significance and structure. Trucking business management: Cases and concepts.
Reason, J., Manstead, A., Stradling, S., Baxter, J., Campbell, K., Reason, J., ... Campbell, K. (1990). Errors and violations on the roads: A real distinction? *Ergonomics, 33*(10/11), 1315–1332. https://doi.org/10.1080/00140139008925335.
Road Safety Authority (2006). Guide to EU rules on driver's hours regulation.
Ronen, A., Chassidim, H. S., Gershon, P., Parmet, Y., Rabinovich, A., Bar-Hamburger, R., ... Shinar, D. (2010). The effect of alcohol, THC and their combination on perceived effects, willingness to drive and performance of driving and non-driving tasks. *Accident Analysis and Prevention, 42*(6), 1855–1865. https://doi.org/10.1016/j.aap.2010.05.006.
Sabahiah, N., Sukor, A., Tarigan, A. K. M., & Fujii, S. (2017). Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F: Psychology and Behaviour, 46*, 509–523. https://doi.org/10.1016/j.trf.2016.09.032.
Sadeghniiat-haghighi, K., Yazdi, Z., & Mohammad, A. (2016). Sleep quality in long haul truck drivers: A study on Iranian national data. *Chinese Journal of Traumatology, 19*(4), 225–228. https://doi.org/10.1016/j.cjtee.2016.01.014.
Sagaspe, P., Taillard, J., Åkersted, T., Bayon, V., Espié, S., Chaumet, G., ... Philip, P. (2008). Extended driving impairs nocturnal driving performances. *PLoS ONE, 3*(10). https://doi.org/10.1371/journal.pone.0003493.
Sagberg, F. (1999). Road accidents caused by drivers falling asleep. *Accident Analysis and Prevention, 31*(6), 639–649. https://doi.org/10.1016/S0001-4575(99)00023-8.
Smith, S. S., Horswill, M. S., Chambers, B., & Wetton, M. (2009). Hazard perception in novice and experienced drivers: The effects of sleepiness. *Accident Analysis and Prevention, 41*(4), 729–733. https://doi.org/10.1016/j.aap.2009.03.016.
Sparrow, A. R., Mollicone, D. J., Kan, K., Bartels, R., Satterfield, B. C., Riedy, S. M., ... Van Dongen, H. P. A. (2016). Naturalistic field study of the restart break in US commercial motor vehicle drivers: Truck driving, sleep, and fatigue. *Accident Analysis and Prevention, 93*, 55–64. https://doi.org/10.1016/j.aap.2016.04.019.
Sullman, M. J. M., Meadows, M. L., & Pajo, K. B. (2002). Aberrant driving behaviours amongst New Zealand truck drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 5*(3), 217–232. https://doi.org/10.1016/S1369-8478(02)00019-0.
Tefft, B. C. (2012). Prevalence of motor vehicle crashes involving drowsy drivers, United States, 1999–2008. *Accident Analysis and Prevention, 45*, 180–186. https://doi.org/10.1016/j.aap.2011.05.028.
Teoh, E. R., Carter, D. L., Smith, S., & McCartt, A. T. (2017). Crash risk factors for interstate large trucks in North Carolina. *Journal of Safety Research, 62*, 13–21. https://doi.org/10.1016/j.jsr.2017.05.002.
Thiffault, P., & Bergeron, J. (2003). Monotony of road environment and driver fatigue: A simulator study. *Accident Analysis and Prevention, 35*, 381–391.
Thompson, J., Newnam, S., & Stevenson, M. (2015). A model for exploring the relationship between payment structures, fatigue, crash risk, and regulatory response in a heavy-vehicle transport system. *Transportation Research Part A: Policy and Practice, 82*, 204–215. https://doi.org/10.1016/j.tra.2015.09.016.
Thompson, J., & Stevenson, M. (2014). Associations between heavy-vehicle driver compensation methods, fatigue-related driving behavior, and sleepiness. *Traffic Injury Prevention, 15*(sup1), S10–S14. https://doi.org/10.1080/15389588.2014.928702.
Ting, P.-H., Hwang, J.-R., Doong, J.-L., & Jeng, M.-C. (2008). Driver fatigue and highway driving: A simulator study. *Physiology & Behavior, 94*(3), 448–453. https://doi.org/10.1016/j.physbeh.2008.02.015.
Tsao, L., Chang, J., & Ma, L. (2017). Fatigue of Chinese railway employees and its influential factors: Structural equation modelling. *Applied Ergonomics, 62*, 131–141. https://doi.org/10.1016/j.apergo.2017.02.021.
Tseng, C., Yeh, M., Tseng, L., Liu, H., & Lee, M. (2016). A comprehensive analysis of factors leading to speeding offenses among large-truck drivers. *Transportation Research Part F: Psychology and Behaviour, 38*, 171–181. https://doi.org/10.1016/j.trf.2016.02.007.
Tzamalouka, G., Papadakaki, M., & Chliaoutakis, J. El. (2005). Freight transport and non-driving work duties as predictors of falling asleep at the wheel in urban areas of Crete. *Journal of Safety Research, 36*(1), 75–84. https://doi.org/10.1016/j.jsr.2004.12.003.
Urie, Y., Velaga, N. R., & Maji, A. (2016). Cross-sectional study of road accidents and related law enforcement efficiency for 10 countries: A gap coherence analysis. *Traffic Injury Prevention, 17*(7), 686–691. https://doi.org/10.1080/15389588.2016.1146823.
Watling, C. N., Armstrong, K. A., Obst, P. L., & Smith, S. S. (2014). Continuing to drive while sleepy: The influence of sleepiness countermeasures, motivation for driving sleepy, and risk perception. *Accident Analysis and Prevention, 73*, 262–268. https://doi.org/10.1016/j.aap.2014.09.021.
Watt, T., Groenvold, M., Bjorner, J. B., Noerholm, V., Rasmussen, N. A., & Bech, P. (2000). Fatigue in the Danish general population. Influence of sociodemographic factors and disease. *Journal of Epidemiology and Community Health, 54*(11), 827–833. https://doi.org/10.1136/jech.54.11.827.
Wheaton, A. G., Chapman, D. P., Presley-Cantrell, L. R., Croft, J. B., & Roehler, D. R. (2013). Drowsy driving—19 states and the district of Columbia, 2009–2010 Retrieved from. *MMWR. Morbidity and Mortality Weekly Report, 61*(51).
Williamson, A. M., Feyer, A.-M., & Friswell, R. (1996). The impact of work practices on fatigue in long distance truck drivers. *Accident Analysis & Prevention, 28*(6), 709–719. https://doi.org/10.1016/S0001-4575(96)00044-9.
Williamson, A., & Friswell, R. (2011). Investigating the relative effects of sleep deprivation and time of day on fatigue and performance. *Accident Analysis and Prevention, 43*(3), 690–697. https://doi.org/10.1016/j.aap.2010.10.013.
Williamson, A., & Friswell, R. (2013). The effect of external non-driving factors, payment type and waiting and queuing on fatigue in long distance trucking. *Accident Analysis and Prevention, 58*, 26–34. https://doi.org/10.1016/j.aap.2013.04.017.

World Health Organization (2013). Media centre road traffic injuries. Retrieved from http://www.who.int/mediacentre/factsheets/fs358/en/index.html#.
Zhang, H., Yan, X., Wu, C., & Qiu, T. Z. (2014). Effect of circadian rhythms and driving duration on fatigue level and driving performance of professional drivers. *Transportation Research Record: Journal of the Transportation Research Board, 2402*(1), 19–27. https://doi.org/10.3141/2402-03.
Zhang, G., Yau, K. K. W., Zhang, X., & Li, Y. (2016). Traffic accidents involving fatigue driving and their extent of casualties. *Accident Analysis and Prevention, 87*, 34–42. https://doi.org/10.1016/j.aap.2015.10.033.