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A comprehensive analysis of factors leading to speeding offenses among large-truck drivers

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ABSTRACT

Much research has demonstrated that speeding is the most common offense among car drivers. However, few studies have focused on this offense among drivers of large trucks. This paper investigates the factors that lead to speeding offenses for drivers of large trucks in Taiwan. The study sample consisted of information for 2101 male large-truck drivers from a national survey in 2012. The results revealed that drivers' daily working hours ranged from 2 to 15 h with a mean of 9.67 h, and that they worked for approximately 25.23 days – and rested only 4.77 days – per month. Among these observed drivers, 11.6% reported having at least one speeding offense over a one-year period. The results of a logistic regression model presented that the factors that influenced speeding offense were not related to job experience. Rather, the driver's demographics (age and education), mental condition (sleep quality), and driving status (yearly distance driven and driving late at night) were significantly linked to speeding offenses.

1. Introduction

According to the vehicle regulations in Taiwan, large trucks are grouped into two categories: those that transport construction materials – including sand and rock – and are usually of a relative large size and carry a heavy weight; and those that move all other forms of goods. Over the past decade, many serious accidents have been linked to the former form of large trucks. This safety problem has received considerable media coverage, and has attracted a great deal of attention from road safety authorities who have found that many large truck drivers have serious speeding problems. Among the six categories of serious traffic offenses, which include speeding, running a red light, running a level crossing, overloading, failure to wear a seat belt, and using a mobile phone while driving, speeding was the most common (Ministry of Transportation, 2011), and was also the most serious infraction, accounting for 50.49% of traffic offenses (Fig. 1). The safety of large trucks has been a considerable concern for road safety authorities and the general public, and has long been a topic of accident analysis literature (Abdel-Rahim, Berrio-Gonzales, Candia, & Taylor, 2006; Zaloshnja & Miller, 2006; Zhu &

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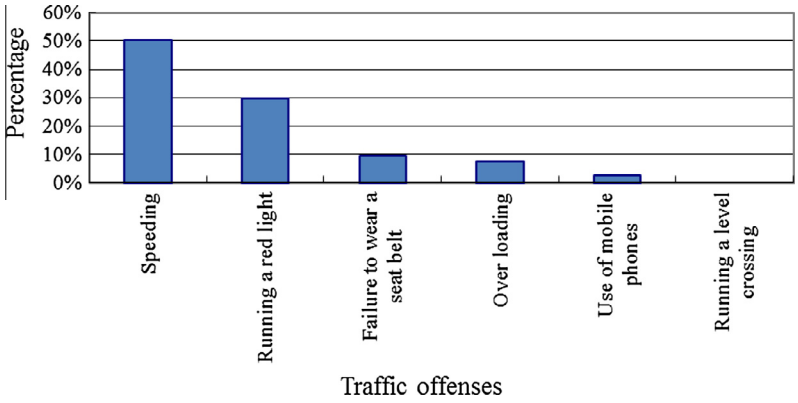

Fig. 1. The percentage of various traffic offenses.

Srinivasan, 2011). The high rate and costs of crashes involving large trucks demonstrates the necessity for continued efforts to increase the safety of trucking operations (Huang, Roetting, McDevitt, Melton, & Smith, 2005; Zaloshnja, Miller, & Spicer, 2000).

Researchers have adopted two approaches for the study of large truck safety. The first emphasizes operational characteristics and design requirements, in comparison with research on other trucks and roadway geometry, in order to anticipate real world safety impacts. This approach mainly evaluates the size and configuration of large truck operations on public highways to further accommodate them through better geometric designs, or regulate them through more stringent laws and more effective enforcement (Debauche & Decock, 2007; Hanley & Forkenbrock, 2005; Harkey, Council, & Zegeer, 1996; Renshaw, 2007). The second approach focuses on large truck safety, and involves analysis of actual crash rates and outcomes (Lempa, Kockelmanb, & Unnikrishnan, 2011). Numerous studies of the latter approach have explored a variety of safety issues related to large trucks, including the effects of vehicle inspection on accidents (Elvik, 2002), the effects of the driving schedules and/or fatigue of truck drivers before accidents took place (Hakkanen & Summala, 2000; Park, Mukherjee, Gross, & Jovanis, 2005), costs for truck-involved accidents (Zaloshnja & Miller, 2004), factors influencing injury severity (Bjornstig & Eriksson, 2008; Khorashadi, Niemeier, Shankar, & Mannering, 2005; Lempa et al., 2011; Zhu & Srinivasan, 2011), and the accident rate/risk for large trucks (Loeb & Clarke, 2007; Lyman & Braver, 2003; Tsai & Su, 2004; Young & Liesman, 2007). However, there has been limited research on examining the offense rates of large trucks (Beilock, 1995; Ministry of Transportation & Communications, 2011), and there is especially a lack of literature concerning the speeding issue among large-truck drivers.

The literature has demonstrated that speeding is a major cause of accidents (Aarts & van Schagen, 2006; Carstenand & Tate, 2005). Speed not only increases the risk of being involved in an accident, but also affects its potential severity (Charbotel, Martin, & Chiron, 2010; Elvik, Christensen, & Amundsen, 2004; Laapotti, Keskinen, Hatakka, & Kat, 2001). Previous literature has defined large trucks as vehicles with a gross vehicle weight rating of over 10,000 lbs and critical to freight movements (Lempa et al., 2011; Zhu & Srinivasan, 2011). The higher crash injury/fatality rate is attributed to the size disparity between large trucks and passenger vehicles, which puts passenger vehicle occupants more at risk (Jermakian, 2012). Studying the speeding issue of large trucks is important, because these vehicles have many unique operating characteristics, such as high gross weight, limited stopping distances, substantial traffic volume, and the habits of the drivers themselves. All of these factors have contributed to a large number of crashes (Chang & Mannering, 1999; Zhu & Srinivasan, 2011) and an increased likelihood of producing severe injuries or fatalities (Chang & Mannering, 1999).

This study investigates large-truck drivers' speeding offenses in Taiwan, and examines the factors that lead to these speeding offenses. Due to there being a lack of sources on speeding by large-truck drivers, the present hypotheses are mainly based on previous truck/large-truck driving literature sources on traffic accidents and/or risk behaviors. Concerning the factors leading to truck/large-truck on accidents and/or risk behavior, most research on the dangers affiliated with their operations cover factors that include age (Campbell, 1991; Sullman, Meadows, & Pajo, 2002), job experience (Campbell, 1991; Häkkänen & Summala, 2001; Kaneko & Jovanis, 1992; McCartt, Rohrbaugh, Hammer, & Fuller, 2000), sleep quality (Anderson et al., 2012; Dagan, Doljansky, Green, & Weiner, 2006; Hakkanen & Summala, 2000; Stoohs, Guilleminault, & Dement, 1993; Taylor & Dorn, 2006), driving mileage (Poulter, Chapman, Bibby, Clarke, & Crundall, 2008; Rodríguez, Rocha, Khattak, & Belzer, 2003), and the time of day (Hertz, 1988; Jovanis, Kaneko, & Lin, 1991). We expect that the factors related to accident and/or risk behavior may also be related to speeding offenses. We assume in the present study that the factors in the above literature sources, including age, job experience, sleep quality, mileage driven, and time of day, may be associated with speeding offenses among large-truck drivers. In addition to the five contributive factors, there is an important factor that previous truck/large truck literature has neglected. There is evidence in the literature concerning vehicle operation that suggests that demographics of education are also associated with speeding behavior (Hemenway & Solnick, 1993; Shinar, 1993; Shinar, Schechtman, & Compton, 2001). Thus, the variable of education was also included in the present analysis.

In particular, this study first focused on investigating the differences in the speeding offense of large-truck drivers across their ages and educational levels. Previous literature has pointed out that younger truck drivers were more frequently involved in accidents (Campbell, 1991). Sullman et al. (2002) have also found that age was negatively correlated with preferred truck drivers' driving speeds and traffic violations, and was also directly correlated with crash involvement. Therefore, we expect large-truck drivers' ages will be a factor for speeding offenses, which is suggested in the following hypothesis:

H1. Younger large-truck drivers are more likely to commit speeding offenses than older ones.

Several studies completed on car driving have found that speeding is associated with less educated drivers (e.g. Shinar, 1993), while other studies have reported that drivers with higher levels of education are more likely to report speeding than drivers with a lower educational level (Hemenway & Solnick, 1993; Shinar et al., 2001). Recently, Newnam, Mamo, and Segni (2014) also found that more educated taxi drivers reported more unsafe driving behaviors, compared to less educated taxi drivers. Thus, we expect large-truck drivers' education level to affect speeding offense, which suggests the following hypothesis:

H2. More educated drivers will report more speeding offenses, compared to less educated drivers.

Fatigue and sleep deprivation have been identified as one of the major causes of truck accidents (Anderson et al., 2012; Dagan et al., 2006). Drivers with untreated sleep apnea, snoring, or sleep-disordered breathing are at increased risk for truck accidents (Hakkanen & Summala, 2000; Stoohs et al., 1993; Taylor & Dorn, 2006). Some studies have indicated that poor sleep quality usually causes insufficient patience (Kamstra, Kramer, & Levi, 2000; Swanson et al., 2011). We expect that large-truck drivers who have poor sleep quality may have less patience when it comes to obeying speed limits and commit more speeding offenses. Thus, it is hypothesized that:

H3. Drivers with poor sleep quality will have more speeding offenses than drivers with a good sleep quality.

A truck driver's experience has been shown to be associated with accident risk, and accident risk is highest among those drivers with less experience (Campbell, 1991; Häkkänen & Summala, 2001; Kaneko & Jovanis, 1992; McCartt et al., 2000). Tseng (2013) also pointed out that new taxi drivers are more likely to commit speeding offenses than experienced ones. We expect that drivers' driving experience will be related to speeding offense. Thus, it is hypothesized that:

H4. Job experience is related to drivers' speeding offenses. New drivers are more likely to commit speeding offenses than more experienced drivers.

Some studies have demonstrated that driving mileage is a determinant factor of in accidents, and more driving mileage is associated with more accidents (Poulter et al., 2008; Rodríguez et al., 2003). We expect that more driving mileage will also result in more speeding offenses. Therefore, the hypothesis in this study is as follows:

H5. Driving mileage is a determinant factor in driver speeding offenses. More driving mileage leads to more speeding offenses.

Previous studies have demonstrated that night-time driving resulted in a higher crash risk for truck drivers (Hertz, 1988; Jovanis et al., 1991). One of the reasons for this may be that police enforcement is less intense at night than in the daytime. Drivers may therefore have more chances to violate the speed limits. Therefore, the assumption of the present study is that a large-truck driver may commit more speeding offenses during nighttime, and the hypothesis proposed is therefore as follows:

H6. Drivers who drive late at night will engage in more speeding offenses than drivers who drive during other times.

Finally, this study provides a comprehensive framework of three major contributive factors: demographics (age and education), mental condition (sleep quality), and driving status (job experience, yearly driving distance, and driving late at night). A better understanding of these relationships can provide road safety authorities with insights into the relations between these factors and speeding behavior so that they can adjust enforcement to reduce speeding offenses and traffic accidents. Data from a recent, nationally representative sample of large trucks is examined to determine the factors affecting overall speeding offenses. This paper focuses on construction material trucks with gross vehicle weight ratings of over 10,000 lbs in Taiwan.

2. Methods

2.1. Participants

Data for the drivers of these large trucks was collected by a national survey conducted by Taiwan's MOTC. Participants were large truck drivers registered with the Department of Motor Vehicles (DMV) as of April 30, 2012, which comprised a total of 19,554 legal drivers. All of the large truck drivers were ordered to attend a one-day safety training course at one of three DMV training centers from 1 May to 30 September, 2012. There were 392 training classes, and for each training class involved approximately 50 drivers. A random sampling of 60 training classes was taken from among a total of 392

according to the ratio of population among the three DMV training centers. In all, 2933 out of all the 19,554 drivers received the questionnaire, with a sampling ratio of 15%. All participants were voluntary, anonymous, and were not compensated. A total of 2686 usable questionnaires were returned and effective, giving a response rate of 91.6% (Table 1). Of these 2686 drivers, there were 2127 drivers (79.2%) who drove the same vehicle throughout the preceding year, and 559 drivers (20.8%) who shared the use of a vehicle. In order to match the speeding offense incidence for both the drivers and vehicles, only the single-vehicle-use drivers were included. Regarding demographics, 99.5% were male and only 0.5% were female, which led us to include only the 2101 male respondents for our final analysis, believing that such a sample would be the most applicably representative of Taiwan's large-trucking population.

Table 3 lists the characteristics of the respondents at the time of the survey. Daily working hours ranged from 2.5 h to 15 h, with a mean of 9.67 h. The majority of the respondents worked from 6 to 12 h (73.9%), although some (5.8%) worked for more than 14 h. As for days off per month, 3.4% did not even take one day off. On average, drivers of large trucks worked approximately for 25.23 days and only took 4.77 days of rest per month. The respondents' ages ranged from 20 to 65, with an average age of 46.00 (S.D. = 8.95). Few respondents held college degrees (3.3%), while the majority of drivers were senior high school (12 years, 46.3%) and junior high school (9 years, 40.7%) graduates. In terms of mental condition, 23.9% of the respondents had relatively poor sleep quality.

The data also show that most of the respondents were senior drivers (94.6%), while only 5.4% were new drivers with less than a year of experience. Yearly driving kilometers ranged from 2500 to 97,000, with an average of 40,975 (S.D. = 22,367). Approximately 20% of the drivers drove late at night (with 17.2% having worked between 00:00 and 06:00), while the remaining 80% drove in the daytime.

2.2. Measures

Information on the drivers' characteristics and driving status during the year preceding the study was collected, including:

(1) Demographics: (a) gender; (b) age – with drivers' ages directly stated by the respondents; and (c) education: "Concerning your educational level, please tick one of the following: 6 years, 9 years, 12 years, and college and above."
(2) Mental conditions: A respondent's mental condition was represented by sleep quality that was measured using the Pittsburgh Sleep Quality Index (PSQI), and described the drivers' sleep quality and disturbance retrospectively over a one-month period based on self-reports (de Pinho et al., 2006; Sabbagh-Ehrlich, Friedman, & Richter, 2005). The inventory consisted of seven components, including sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The PSQI produced a global score between 0 and 21. For the present study, a driver with a sleep quality index score of higher than 9.0 was classified as having poor sleep quality.
(3) Driving status: (a) job experience in years: "Concerning your job experience in years, please tick one of the following periods: less than 1, 1–3, 4–6, 7–9, 10–12, 13–15, 16–18, 19–24, more than 24 years." Each driver's job experience in terms of years was classified into two groups based on an experience of one year: a driver whose job experience was less than one year was defined as a new driver, and a driver whose experience was more than one year was defined as a senior driver; (b) yearly kilometers driven: "Concerning your yearly kilometers driven, please tick one of the following: less than 10,000 km, 10,000–30,000 km, 30,000–60,000 km, and more than 60,000 km; and (c) late-night driving: "Concerning your daily working periods, please tick the periods out of the following (multi-choice): 00:00–04:00, 04:00–06:00, 06:00–08:00, 08:00–10:00, 10:00–12:00, 12:00–14:00, 14:00–16:00, 16:00–18:00, 18:00–20:00, 20:00–22:00, 22:00–24:00." In order to examine whether or not a large truck driver driving late at night had different outcomes for speeding violations, the definition of driving late at night was defined as driving during the 00:00–06:00 period.
(4) Speeding offense: the number of cited speeding violations in the one-year period during the year preceding the study. The question was posed as that "How many speeding tickets (issued by the police) have you received during the last year?"

2.3. Study variables and analytical approach

In the present study, the drivers' speeding offense is examined in two ways. The first is drivers' exposure to speeding offenses, and the second is drivers' compliance/or non-compliance with the speed limits. For the former, exposure to speeding offenses is determined by speeding tickets per million kilometers – which is then calculated using the above collected information concerning respondents' self-reporting of speeding tickets and mileage driven. In terms of the latter, compliance/or non-compliance with the speed limit is determined by whether a driver has had any (at least one) speeding ticket. In order to quantify the likelihood of a speeding offense, a logistic regression model was employed to explore a large truck driver's compliance/non-compliance with the speed limit, and indicate how demographics (age and educational level), mental condition (sleep quality), driving status (job experience, yearly distance driven, and driving late at night) are related to speeding offenses. In order to differentiate the effects of each influencing factor on speeding violations, a correlation analysis between selected explanatory variables was conducted to detect whether multi-collinearity exists. When the dependent

Table 1
Drivers' population, sampling amount, returned samples and return rate.

Areas	Population amount	Sampling amount	Returned samples	Return rate (%)
North Training Center of MVD	10,717	1608	1463	90.1
Central Training Center of MVD	4381	657	604	91.9
South Training Center of MVD	4456	668	619	92.7
Total	19,554	2933	2686	91.6

Table 2
Frequencies of speeding offenses in the one-year-period ($N = 2101$).

Frequencies of speeding offenses	Number of large truck drivers	Percentage
0	1858	88.4
1	178	8.5
2	46	2.2
3	12	0.6
4	3	0.1
5	2	0.1
6	1	0.0
7	0	0.0
8	1	0.0

Table 3
Respondent drivers' basic characteristics, having at least one speeding ticket.

Basic characteristics	Number of drivers (%)	Percentage of having at least one speeding fine
Social-demographics		
Age		
<30	79(3.8)	5.1
30–39	455(21.8)	11.4
40–49	820(39.3)	11.3
50–59	617(29.6)	11.7
60 and up	115(5.5)	16.5
Education		
6 years	201(9.7)	14.9
9 years	845(40.7)	14.8
12 years	960(46.3)	8.5
College and up	69(3.3)	4.3
Mental condition		
Sleep quality		
Good	1482(76.1)	10.8
Poor	465(23.9)	16.3
Driving status		
Job experience		
<1 year	110(5.4)	9.1
More than 1 year	1939(94.6)	11.8
Yearly kilometers driven		
<10,000	302(15.6)	5.0
10,000–30,000	361(18.7)	8.6
30,000–60,000	692(35.8)	11.0
60,000 and up	578(29.8)	18.7
Driving late at night		
Yes	317(17.2)	19.6
No	1524(82.8)	10.3
Total	2101(100.0)	11.6

variable is dichotomous, the binary logistic regression is widely applied to test the association between a dependent variable and the related potential factors, in order to rank the relative importance of independent variables, and to assess interaction effects (Hosmer & Lemeshow, 1989; Yannis, Golias, & Papadimitriou, 2005). Thus, the dependent variable was set as 1 (violation) if the respondent had at least one speeding violation in the survey, and 0 (compliance) otherwise. The logistic regression coefficients were used to estimate odds ratios for each of the independent variables in the model. Moreover, in addition to exploring the main effect of the independent variables, the significance of inter-factor interaction was also tested.

3. Results

3.1. Speeding offense rate

Table 2 presents the respondents' speeding offense frequencies in the one-year-period. Of the observed drivers, 11.6% reported at least one speeding offense, while the others (88.4%) did not report any speeding offense. Table 3 shows the percentages for the different variable groups of respondents who had at least one speeding offense. Table 4 indicates the overall large-truck drivers' speeding tickets, yearly distance driven, and speeding tickets per million kilometers by different explanatory variables.

3.1.1. Driver's demographics

Those respondents over 60 years of age reported a higher speeding offense rate than the overall average (16.5% vs. 11.6%), and those younger than 30 years old reported the lowest speeding offense rate (5.1%) (Table 3). The respondents with the lowest educational levels (6 years) reported a much higher speeding offense rate (14.9% vs. 4.3%) than those with the highest educational levels (college and up). Generally, the results presented that the respondents with the lower educational levels reported a higher speeding offense rate than the respondents with higher educational levels. For speeding tickets per million kilometers, young drivers (<30 years old) had the lowest incidence of speeding offenses, and older drivers (60 years and above) had the highest incidence (1.74 vs. 6.55). In general, more highly educated drivers reported fewer speeding tickets per million kilometers than the drivers with lower educational levels (Table 4).

3.1.2. Driver's mental condition

Table 3 presents the percentages of respondents who had at least one speeding offense in the two types of sleep quality groups (good and poor). The respondents who belonged to the good sleep quality group reported having a lower speeding offense rate than the drivers in the poor sleep quality group (10.8% vs. 16.3%). For speeding tickets per million kilometers, Table 4 reveals that drivers with a good sleep quality reported fewer speeding offenses than drivers with poor sleep quality (3.51 vs. 6.12).

3.1.3. Driver's driving status

Regarding job experience, Table 3 reveals that more experienced drivers reported a higher speeding offense rate than new drivers (11.8% vs. 9.1%). In terms of distance driven, drivers who had a greater yearly mileage reported a higher speeding offense rate than drivers with a lower yearly mileage. In terms of work time, drivers who drove late at night reported the highest speeding offense rate. For speeding tickets per million kilometers, experienced drivers (job experience of more than one year) had a higher speeding offense rate than new drivers (job experience of less than one year) (4.73 vs 3.96). Drivers who reported a higher yearly distance driven had fewer speeding tickets per million kilometers. Drivers who drove late at night reported a higher rate of speeding offenses than drivers who drove during other times (5.83 vs. 3.62).

3.2. Results of estimated speeding offenses

The results showed that the values of correlation coefficients between independent variables are not high (less than 0.3) and would not result in the problem of multi-collinearity. Among the explanatory factors, the demographics (age and education), mental condition (sleep quality), and driving status (yearly kilometers driven and driving late at night) were significant in the logistic regression model (Table 5). Older drivers were more likely to commit speeding offenses than younger drivers. Setting the younger drivers (less than 30 years old) as the reference group, the other age groups (30–39, 40–49, 50–59, and 60 and above) were significantly/or marginally significantly more likely to be issued a speeding ticket with odds ratios of 1.868, 1.872, 1.886, and 3.093 respectively, meaning that the results were contrary to hypothesis H1. With regard to education, the more educated drivers reported fewer speeding offenses than the less educated ones. While the more educated group (college and up) was set as the reference group, the other education groups (6 years, 9 years, and 12 years) were significantly more likely to be issued a speeding ticket – with odds ratios of 9.564, 9.543, and 5.027 respectively, which did not support hypothesis H2.

In terms of mental condition, the poor sleep quality group were more likely (odds = 1.486, p-value = 0.019) to commit speeding offenses than those in the good sleep quality group, which confirmed hypothesis H3. In terms of driving status, job experience was not a significant factor for speeding in the regression model, meaning that hypothesis H4 was not supported. The results showed that more mileage driven corresponded to a higher rate of speeding offense, and those who drove late at night were more than 50% likely to commit speeding offenses than those who drove at other times – thus confirming hypotheses H5 and H6.

4. Discussion

Previous literature about automobile driving indicates that speeding is a major cause of accidents (Aarts & van Schagen, 2006; Carstenand & Tate, 2005). Speed not only increases the risk of being involved in an accident, but also affects the

Table 4
Large truck drivers' speeding tickets, yearly distance driven, and speeding tickets per million kilometers by demographics, mental condition, and driving status (N = 2101).

Driver's characteristics	Number of drivers	Total speeding tickets[a]	Average yearly distance driven (km)	Speeding tickets per driver[b]	Speeding tickets per million km[c]
Demographics					
Age					
<30	79	5	36,300	0.06	1.74
30–39	455	77	42,051	0.17	4.02
40–49	820	125	42,187	0.15	3.61
50–59	617	96	39,815	0.16	3.91
60 and up	115	28	37,157	0.24	6.55
Education					
6 years	201	37	35,551	0.18	5.18
9 years	845	179	41,692	0.21	5.08
12 years	960	116	41,975	0.12	2.88
College and up	69	7	37,311	0.10	2.71
Mental condition					
Sleep quality					
Good	1482	210	40,405	0.14	3.51
Poor	465	124	43,597	0.27	6.12
Driving status					
Job experience					
<1 years	110	13	25,000	0.12	4.73
More than 1 year	1939	323	42,030	0.17	3.96
Yearly driving kilometers					
<10,000	302	19	5265	0.06	11.95
10,000–30,000	361	48	19,931	0.13	6.67
30,000–60,000	692	101	47,471	0.15	3.07
60,000 and up	578	159	65,000	0.28	4.23
Driving late at night					
Yes	317	84	45,437	0.26	5.83
No	1524	223	40,430	0.15	3.62
Total	2101	337	40,975	0.16	3.91

[a] Total speeding tickets in the survey year.
[b] Total speeding tickets divided by number of drivers.
[c] ([a] ∗ 1,000,000)/(average yearly distance driven ∗ number of drivers).

severity of an accident (Charbotel et al., 2010; Elvik et al., 2004; Laapotti et al., 2001). However, as already stated, few studies have explored such violations among drivers of large trucks. The present results reveal that a considerable number (11.6%) of large-truck drivers committed speeding offenses and received at least one speeding ticket over a one-year period, which is in line with previous studies that show that speeding is the most common violation among drivers (Nallet, Bernard, & Chiron, 2010; Nilsson, 2004). The present results also demonstrate that large truck drivers' demographics (age and education), mental condition (sleep quality), and driving status (yearly distance driven and driving late at night), were related to speeding offenses.

For demographics factors, we hypothesized that younger, more educated drivers would report engaging in more speeding offenses compared to older, less educated drivers. However, our findings reported the opposite. Previous studies focusing on car driving have concluded that young drivers are the core group who are at greater risk of being involved in risky driving. Young drivers travel at higher speeds than older drivers (Quimby & Watts, 1981) and perceive themselves as being less likely to be involved in a crash than other drivers (Brown & Groeger, 1998; Finn & Bragg, 1986; Jonah, 1986; Mathews & Moran, 1986; Renge, 1998). We explain the present findings by describing key characteristics of the sample and cultural ideologies of the region. First, to be a large-truck driver in Taiwan, one must have at least 3 years of professional small car or truck driving experience. Young large-truck drivers may not have sufficient driving skills or experience to confidently drive under the watchful eye of law enforcement officials, so they drive more cautiously. Moreover, because young large-truck drivers are required to remember a large number of roads and be familiar with the positions of various construction sites and other locations, they may drive more carefully and therefore use speed less. As to education, some studies concerning automobile driving have reported that drivers with higher educations were more likely to speed (Hemenway & Solnick, 1993; Shinar et al., 2001), or reported more unsafe driving behaviors (Newnam et al., 2014) than drivers with lower educational levels. However, the present results present a different outcome, which is consistent with Shinar's (1993) findings that speeding behavior is related to less educated drivers. An explanation is that the difference may also come from the characteristics of the sample and cultural characteristics of the region. However, the literature on the speeding behavior of work-related populations is very limited. Newnam et al. (2014), who conducted studies on work-related (taxi) driving, did not identify any significant relationship between educational levels and speeding behavior. Tseng (2013), who conducted work-related (taxi)

Table 5
Percentage of having at least one speeding ticket and odds ratios by demographics, mental condition, and driving status ($N = 2101$).

Drivers' characteristics	*B*	Wald	Odds ratio	*P*-value	95% C.I.
Demographics					
Age		3.473		0.072	
<30			1(reference)		
30–39	0.625	1.279	1.868	0.088	0.633–5.517
40–49	0.627	1.337	1.872	0.068	0.647–5.418
50–59	0.634	1.326	1.886	0.069	0.641–5.548
60 and up	1.129	3.165	3.093	0.025	1.891–10.734
Education		18.540		0.000	
6 years	2.258	4.607	9.564	0.032	1.217–75.171
9 years	2.256	4.882	9.543	0.027	1.290–70.583
12 years	1.615	2.500	5.027	0.114	0.679–37.207
College and up			1(reference)		
Mental condition					
Sleep quality					
Good			1(reference)		
Poor	0.396	5.502	1.486	0.019	1.067–2.069
Driving status					
Job experience					
<1 year			1(reference)		
More than 1 year	−0.108	0.066	0.898	0.797	0.394–2.042
Yearly driving kilometers		29.429		0.000	
<10,000			1(reference)		
10,000–30,000	0.610	2.743	1.841	0.098	0.894–3.789
30,000–60,000	0.915	7.651	2.496	0.006	1.305–4.773
60,000 and up	1.465	20.184	4.329	0.000	2.284–8.204
Driving late at night					
Yes	0.601	10.639	1.823	0.001	1.271–2.616
No			1(reference)		
Constant	−5.742	23.800	0.003	0.000	

driving in Taiwan, also found that educational level of taxi drivers are not related to speeding offenses. The present study successfully demonstrated that more educated drivers reported being engaged in fewer speeding offenses. This is still far from addressing any common consensus on the effects between educational levels and speeding. Therefore, it is suggested that future studies should focus more attention on this issue and examine it in greater depth.

The present results also support the hypothesis that sleep quality is related to drivers' speeding offense. Drivers who do not get enough sleep report more speeding offenses than drivers who get an adequate amount of sleep. Sleep deprivation/disorder has been identified as one of the major causes of motor vehicle accidents (Aldrich, 1989; Brown, 1994; Findley, Fabrizio, Thommi, & Suratt, 1989; Findley, Unverzagt, & Suratt, 1988; Hakkanen & Summala, 2000; Sagberg, 1999; Stoohs et al., 1993; Taylor & Dorn, 2006; Young, Blustein, Finn, & Palta, 1997). The present results also support such claims. The reason may be that poor sleep quality may cause a lack of patience (Kamstra et al., 2000; Swanson et al., 2011), and impatient drivers may be less likely to obey traffic regulations and speed limits.

A large-truck driver's driving mileage is also considerable, with approximately thirty percent of the drivers in this study having driven more than 60,000 km per year. The present results also indicate that driving mileage is a determinant factor in term of a large truck driver's speeding offense. This is in line with many previous studies that concluded driving mileage is the most important predictor of driver violations and accident involvement (Elvik et al., 2004; Gebers & Peck, 1992; Kaneko & Jovanis, 1992; Lourens, Vissers, & Jessurun, 1999; Massie, Green, & Campbell, 1997; Mercer, 1989; Mesken, Lajunen, & Summala, 2002; Peck, 1993; Peck & Kuan, 1983).

In addition, nearly twenty percent of drivers work late at night, perhaps because large truck operations favor nighttime travel (Lempa et al., 2011) and large truck use is often prohibited during times of heavy traffic congestion in cities (Regehr, 2009; Woodrooffe, 2009). Hertz (1988) and Jovanis et al. (1991) found nighttime driving results in a higher crash risk for truck drivers. The present results also reveal that drivers who drive late at night are significantly more likely to commit speeding offenses than those who drive at other times. One of the possible reasons is that police enforcement is less rigorous at night than during the daytime, so there is less risk of police intervention. Kockelman and Ma (2007) pointed out non-bright conditions are estimated to increase the probability of fatality, perhaps because there are higher speed variations at nighttime. Therefore, it is suggested that road safety authorities need to increase nighttime safety enforcement.

The safety of large trucks has attracted considerable attention from traffic safety authorities and the general public, and the importance of trucking to freight logistics and its impact on the economic well-being of a nation is well acknowledged in the literature (Zhu & Srinivasan, 2011). The high rate and cost of crashes involving large trucks demonstrate the necessity for continued efforts to increase the safety of trucking operations in the United States and other countries (Huang et al., 2005; Zaloshnja et al., 2000). The present study indicates that drivers of large trucks tend to commit speeding offenses more often

than other traffic offenses, and successfully demonstrates the influential factors for speeding offenses. While previous studies found that it is difficult to impose adherence to traffic regulations by solely depending on fear of penalties (Sunshine & Tyler, 2003; Tyler, 1990, 2006), the present study suggests that appropriate speeding prevention strategies should target large-truck drivers.

In summary, accounting for previous literature, the present study is the first of its kind to explore the speeding issue among large truck drivers. Our findings contribute to the large truck driving literature, and further provide valuable practical strategies for road safety. First, the present findings show that both large-truck drivers' working hours and mileage driven are considerable. As is suggested in the present study, safer working conditions should be encouraged. For example, working rules and regulations should aim at reducing the stress of large-truck drivers to safer levels, and working hours should be arranged so that they can drive without feeling stress or fatigue. Moreover, the findings indicate that large-truck drivers' educational level is related to speeding offenses. Hence, appropriate speeding prevention strategies are required to target large-truck drivers, especially those with lower educational levels. For practical purposes, road safety authorities and truck companies may need to provide effective safety education and/or training for drivers to further discourage their speeding behavior. Finally, our findings demonstrate that large-truck drivers were subject to a considerable amount of speeding offenses – which reported that law enforcers (police) are concerned that professional drivers in general ignore traffic regulations more than the general population – and that it is difficult to establish orderly driving conditions by solely depending on fear of penalties (Sunshine & Tyler, 2003; Tyler, 1990, 2006).

Although, the present study has identified a number of potentially useful safety intervention methods aimed at speed limit offenders, some limitations of this study should be acknowledged. First, while issues of gender may be important in studying road safety, collecting equally effective samples representative of large-truck drivers of both sexes is difficult, due to the overwhelming majority of drivers being male – with a relatively tiny minority being female. Second, because the present study is based on self-reporting, there is a natural tendency for respondents to answer questions in a socially moral fashion, especially in health-related and safety-related surveys (Shinar et al., 2001). Thus, future studies using more objective measures are needed to further confirm the present results. For example, speeding offense could be targeted by utilizing data from police authorities.

References

Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis and Prevention, 38*(2), 215–224.

Abdel-Rahim, A., Berrio-Gonzales, S. G., Candia, G., & Taylor, W. (2006). Longer combi-nation vehicle safety: A comparative crash rate analysis. Final Report. National Institute for Advanced Transportation Technology (NIATT) Report Number N06-21, Idaho.

Aldrich, M. S. (1989). Automobile accidents in patients with sleep disorders. *Sleep, 12*(6), 487–494.

Anderson, J. E., Govada, M., Steffen, T. K., Thorne, C. P., Varvarigou, V., Kales, S. N., & Burks, S. V. (2012). Obesity is associated with the future risk of heavy truck crashes among newly recruited commercial drivers. *Accident Analysis and Prevention, 49*, 378–384.

Beilock, R. (1995). Schedule-induced hours-of-service and speed limit violations among tractor-trailer drivers. *Accident Analysis and Prevention, 27*(1), 33–42.

Bjornstig, U., & Eriksson, A. (2008). Passenger car collision fatalities – special emphasis on collisions with heavy vehicles. *Accident Analysis and Prevention, 40*(1), 158–166.

Brown, I. D. (1994). Driver fatigue. *Human Factors, 36*, 298–314.

Brown, I., & Groeger, J. (1998). Risk perception and decision taking during the transition between novice and experienced driver status. *Ergonomics, 31*(4), 585–597.

Campbell, K. L. (1991). Fatal accident involvement rates by driver age for large trucks. *Accident Analysis and Prevention, 23*, 287–295.

Carstenand, O. M. J., & Tate, F. N. (2005). Intelligent speed adaptation: Accident savings and cost–benefit analysis. *Accident Analysis and Prevention, 37*(3), 407–416.

Chang, L. Y., & Mannering, F. (1999). Analysis of injury severity and vehicle occupancy in truck-and-non-truck-involved accidents. *Accident Analysis and Prevention, 31*, 579–592.

Charbotel, B., Martin, J. L., & Chiron, M. (2010). Work-related versus non-work-related road accidents, developments in the last decade in France. *Accident Analysis and Prevention, 42*, 604–611.

Dagan, Y., Doljansky, J. T., Green, A., & Weiner, A. (2006). Body mass index (BMI) as a first line screening criterion for detection of excessive daytime sleepiness among professional drivers. *Traffic Injury Prevention, 7*(1), 44–48.

de Pinho, R. S. N., da Silva-Junior, F. P., Bastos, J. P. C., Maia, W. S., de Mello, M. T., de Bruin, V. M. S., & de Bruin, P. F. C. (2006). Hypersomnolence and accidents in truck drivers: A cross-sectional study. *Chronobiology International, 23*(5), 963–971.

Debauche, W., & Decock, D. (2007). Working group on longer and heavier goods vehicles (LHVs): Multidisciplinary approach to the issue). Belgian Road Research Centre. Appendix to the BRRC Bulletin Number 70, Brussels, Belgium. Available at <http://www.brrc.be/pdf/bulletin en/bul en70t.pdf>.

Elvik, R. (2002). The effect on accidents of technical inspections of heavy vehicles in Norway. *Accident Analysis and Prevention, 34*(6), 753–762.

Elvik, R., Christensen, P., & Amundsen, A. (2004). Speed and road accidents: an evaluation of the POWER model. Report 740/2004. Institute of Transport Economics (TØI), Oslo.

Findley, L. J., Fabrizio, M., Thommi, G., & Suratt, P. M. (1989). Severity of sleep apnea and automobile crashes. *New England Journal Medicine, 320*(13), 868–869.

Findley, L. J., Unverzagt, M. E., & Suratt, P. M. (1988). Automobile accidents involving patients with obstructive sleep apnea. *American Review of Respiratory Disease, 138*, 337–340.

Finn, P., & Bragg, B. (1986). Perception of risk of an accident by younger and older drivers. *Accident Analysis and Prevention, 18*(4), 289–298.

Gebers, M. A., & Peck, R. C. (1992). The identification of high-risk older drivers through age-mediated point systems. *Journal of Safety Research, 23*, 81–93.

Hakkanen, H., & Summala, H. (2000). Sleepiness at work among commercial truck drivers. *Sleep, 23*(1), 49–57.

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*, 187–196.

Hanley, P. F., & Forkenbrock, D. J. (2005). Safety of passing longer combination vehicles on two-lane highways. *Transportation Research Part A, 39*, 1–15.

Harkey, D. L., Council, F. M., & Zegeer, C. V. (1996). Operational characteristics of longer combination vehicles and related geometric design issues. *Transportation Research Record, 1523*, 22–28.

Hemenway, D., & Solnick, S. (1993). Fuzzy dice, dream cars, and indecent gestures: Correlates of driver behavior. *Accident Analysis and Prevention, 25*(2), 161–170.

Hertz, R. P. (1988). Tractor-trailer driver fatality: The role of nonconnective rest in a sleeper berth. *Accident Analysis and Prevention, 20*(6), 429–431.
Hosmer, D. W., & Lemeshow, S. (1989). *Applied logistic regression*.New York: Wiley.
Huang, Y.-H., Roetting, M., McDevitt, J. R., Melton, D., & Smith, G. S. (2005). Feedback by technology: Attitudes and opinions of truck drivers. *Transportation Research Part F, 8*, 277–297.
Jermakian, J. (2012). Crash avoidance potential of four large truck technologies. *Accident Analysis and Prevention, 49*, 338–346.
Jonah, B. (1986). Accident risk and risk-taking behaviour among young drivers. *Accident Analysis and Prevention, 18*(4), 255–271.
Jovanis, P. P., Kaneko, T., & Lin, T. D. (1991). Exploratory analysis of motor carrier accident risk and daily driving patterns. In *70th annual meeting of transportation research board*. Washington, DC: Transportation Research Board.
Kamstra, M. J., Kramer, L. A., & Levi, M. D. (2000). Losing sleep at the market: The daylight saving anomaly. *The American Economic Review*. September.
Kaneko, T., & Jovanis, P. P. (1992). Multiday driving patterns and motor carrier accident risk: A disaggregate analysis. *Accident Analysis and Prevention, 24*, 437–456.
Khorashadi, A., Niemeier, D., Shankar, V., & Mannering, F. (2005). Differences in rural and urban driver-injury severities in accidents involving large-trucks: An exploratory analysis. *Accident Analysis and Prevention, 37*(5), 910–921.
Kockelman, K. M., & Ma, J. (2007). Freeway speeds and speed variations preceding crashes, within and across lanes. *Journal of the Transportation Research Forum, 46*(1), 43–61.
Laapotti, S., Keskinen, E., Hatakka, M., & Kat, A. (2001). Novice drivers' accidents and violations – a failure on higher or lower hierarchical levels of driving behaviour. *Accident Analysis and Prevention, 33*, 759–769.
Lempa, J. D., Kockelmanb, K. M., & Unnikrishnan, A. (2011). Analysis of large truck crash severity using heteroskedastic ordered probit models. *Accident Analysis and Prevention, 43*, 370–380.
Loeb, P. D., & Clarke, W. A. (2007). The determinants of truck accidents. *Transportation Research Part E, 43*(4), 442–452.
Lourens, P. F., Vissers, J. A. M. M., & Jessurun, M. (1999). Annual mileage, driving violations, and accident involvement in relation to drivers' sex, age, and level of education. *Accident Analysis and Prevention, 31*, 593–597.
Lyman, S., & Braver, E. R. (2003). Occupant deaths in large truck crashes in the United States: 25 years of experience. *Accident Analysis and Prevention, 35*(5), 731–739.
Massie, D. L., Green, P. E., & Campbell, K. L. (1997). Crash involvement rates by driver gender and the role of average annual mileage. *Accident Analysis and Prevention, 29*, 675–685.
Mathews, M., & Moran, A. (1986). Age differences in male drivers' perception of accident risk: The role of perceived driving ability. *Accident Analysis and Prevention, 18*(4), 299–313.
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*, 493–504.
Mercer, G. W. (1989). Traffic accidents and convictions: Group totals versus rate per kilometer driven. *Risk Analysis, 9*, 71–77.
Mesken, J., Lajunen, T., & Summala, H. (2002). Interpersonal violations, speeding violations and their relation to accident involvement in Finland. *Ergonomics, 7*, 469–483.
Ministry of Transportation and Communications (2011). Survey on Large Truck Drivers' Driving Behaviors in Taiwan. <http://www.motc.gov.tw>.
Nallet, N., Bernard, M., & Chiron, M. (2010). Self-reported road traffic violations in France and how they have changed since 1983. *Accident Analysis and Prevention, 42*, 1302–1309.
Newnam, S., Mamo, W., & Segni, G. (2014). Exploring differences in driving behaviour across age and years of education of taxi drivers in Addis Ababa, Ethiopia. *Safety Science, 68*, 1–5.
Nilsson, G. (2004). *Traffic safety dimensions and the power model to describe the effect of speed on safety*. Bulletin 221, Lund Institute of Technology, Lund.
Park, S.-W., Mukherjee, A., Gross, F., & Jovanis, P. P. (2005). Safety implications of multiday driving schedules for truck drivers: A comparison of field experiment and crash data analysis. *Transportation Research Record, 1922*, 167–174.
Peck, R. C. (1993). The identification of multiple accident correlates in high risk drivers with specific emphasis on the role of age, experience and prior traffic violation frequency. *Paper presented at the behavioral factors that determine accident rates symposium* (Vol. 9, pp. 145–166). Santa Monica, CA, USA: Alcohol, Drugs & Driving.
Peck, R. C., & Kuan, J. (1983). A statistical model of individual accident risk prediction using driver record, territory and other biographical factors. *Accident Analysis and Prevention, 15*, 371–393.
Poulter, D. R., Chapman, P., Bibby, P. A., Clarke, D. D., & Crundall, D. (2008). An application of the theory of planned behaviour to truck driving behaviour and compliance with regulations. *Accident Analysis & Prevention, 40*, 2058–2064.
Quimby, A., & Watts, G. (1981). *Human factors and driving experience*.Crowthorne, Berkshire: Transport and Road Research Laboratory Report LR1004.
Regehr, J. (2009). *Department of civil engineering*. University of Manitoba. Personal Interview.
Renge, K. (1998). Drivers' hazard and risk perception, confidence in safe driving, and choice of speed. *IATSS Research, 22*(2), 103–110.
Renshaw, N. (2007). Longer and Heavier Lorries (LHLs) and the Environment. Position Paper. European Federation for Transport and Environment. Available at <http://www.transportenvironment.org/Downloads-req-getit-lid-453.html>.
Rodríguez, D. A., Rocha, M., Khattak, A. J., & Belzer, M. H. (2003). Effects of truck driver wages and working conditions on highway safety: Case study. *Transportation Research Record: Journal of the Transportation Research Board, 1833*, 95–102.
Sabbagh-Ehrlich, S., Friedman, L., & Richter, E. D. (2005). Working conditions and fatigue in professional truck drivers at Israeli ports. *Injury Prevention, 11*(2), 110–114.
Sagberg, F. (1999). Road accidents caused by drivers falling asleep. *Accident Analysis and Prevention, 31*(6), 639–649.
Shinar, D. (1993). Demographic and socioeconomic correlates of safety belt use. *Accident Analysis and Prevention, 25*, 745–755.
Shinar, D., Schechtman, E., & Compton, R. (2001). Self-reports of safe driving behaviors in relationship to sex, age, education and income in the US adult driving population. *Accident Analysis and Prevention, 33*, 111–116.
Stoohs, R. A., Guilleminault, C., & Dement, W. C. (1993). Sleep apnea and hypertension in commercial truck drivers. *Sleep, 16*, S11–S14.
Sullman, M. J. M., Meadows, M. L., & Pajo, K. B. (2002). Aberrant driving behaviours amongst New Zealand truck drivers. *Transportation Research Part F, 5*, 217–232.
Sunshine, J., & Tyler, T. R. (2003). The role of procedural justice and legitimacy in shaping public support for policing. *Law & Society, 37*, 513–548.
Swanson, L. M., Arnedt, J. T., Rosekind, M. R., Belenky, G., Balkin, T. J., & Drake, C. (2011). Sleep disorders and work performance: Findings from the 2008 National Sleep Foundation Sleep in America poll. *Journal of Sleep Research, 20*, 487–494.
Taylor, A. H., & Dorn, L. (2006). Stress, fatigue, health, and risk of road traffic accidents among professional drivers: The contribution of physical inactivity. *Annual Review of Public Health, 27*, 371–391.
Tsai, M.-C., & Su, C.-C. (2004). Scenario analysis of freight vehicle accident risks in Taiwan. *Accident Analysis Prevention, 36*(4), 683–690.
Tseng, C. M. (2013). Operating styles, working time and daily driving distance in relation to a taxi driver's speeding offenses in Taiwan. *Accident Analysis and Prevention, 52*, 1–8.
Tyler, T. R. (1990). *Why people obey the law*.London: Yale University Press.
Tyler, T. R. (2006). Psychological perspective on legitimacy and legitimation. *Annual Review of Psychology, 57*, 375–400.
Woodrooffe, J. (2009). *Director, transportation research institute*. University of Michigan (Personal Interview).
Yannis, G., Golias, J., & Papadimitriou, E. (2005). Driver age and vehicle engine size effects on fault and severity in young motorcyclists accidents. *Accident Analysis and Prevention, 37*, 327–333.
Young, T., Blustein, J., Finn, L., & Palta, M. (1997). Sleep-disordered breathing and motor vehicle accidents in a population-based sample of employed adults. *Sleep, 20*(8), 608–613.

Young, R. K., & Liesman, J. (2007). Estimating the relationship between measured wind speed and overturning truck crashes using binary logit model. *Accident Analysis and Prevention, 39*(3), 574–580.

Zaloshnja, E., Miller, T. R., & Spicer, R. (2000). Cost of large truck-and bus-involved crashes. Washington, DC: Federal Motor Carrier Safety Administration. Final Report available at <http://ai.volpe.dot.gov/CarrierResearchResults/CarrierResearchResults.asp?file=PDFs/CCT_FinalReport.pdf>.

Zaloshnja, E., & Miller, T. R. (2004). Costs of large truck-involved crashes in the United States. *Accident Analysis and Prevention, 36*, 801–808.

Zaloshnja, E., & Miller, T. (2006). *Unit costs of medium and heavy truck crashes*.Washington, DC: Federal Motor Carrier Safety Administration.

Zhu, X., & Srinivasan, S. (2011). Modeling occupant-level injury severity: An application to large-truck crashes. *Accident Analysis and Prevention, 43*, 1427–1437.