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The impacts of multiple rest-break periods on commercial truck driver's crash risk

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ABSTRACT

Introduction: Driver fatigue has been a major contributing factor to fatal commercial truck crashes, which accounted for about 10% of all fatal motor vehicle crashes that happened between 2009 and 2011. Commercial truck drivers' safety performance can deteriorate easily due to fatigue caused by long driving hours and irregular working schedules. To ensure safety, truck drivers often use off-duty time and short rest breaks during a trip to recover from fatigue. *Method:* This study thoroughly investigates the impacts of off-duty time prior to a trip and short rest breaks on commercial truck safety by using Cox proportional hazards model and Andersen–Gill model. *Results:* It is found that increasing total rest-break duration can consistently reduce fatigue-related crash risk. Similarly, taking more rest breaks can help to reduce crash risk. The results suggest that two rest breaks are generally considered enough for a 10-hour trip, as three or more rest breaks may not further reduce crash risk substantially. Also, the length of each rest break does not need to be very long and 30 min is usually adequate. In addition, this study investigates the safety impacts of when to take rest breaks. It is found that taking rest breaks too soon after a trip starts will cause the rest breaks to be less effective. *Practical applications:* The findings of this research can help policy makers and trucking companies better understand the impacts of multiple rest-break periods and develop more effective rules to improve the safety of truck drivers.

1. Introduction

1.1. Background

Based on a 2013 Federal Motor Carrier Safety Administration (FMCSA, 2013) report, there are 2983, 3271, and 3341 fatal crashes involving commercial trucks in 2009, 2010, and 2011, respectively. They account for about 10% of all fatal motor vehicle crashes during these three years. Also, the estimated total costs of all commercial truck crashes are $79 billion, $84 billion, and $87 billion in 2009, 2010, and 2011, respectively. These alarming facts show that commercial trucks are a major contributing factor to fatal motor vehicle crashes that cause significant losses of lives and productivity every year. Among the possible causes for fatal commercial truck crashes, driver fatigue has been identified as a major factor (FMCSA, 2006) because driver's performance can easily deteriorate due to long hours of driving or irregular working schedules. Sweeney, Ellingstad, Eastwood, Weinstein, and Loeb (1995) investigated 107 single-vehicle heavy truck crashes and categorized them as either fatigued-related or non-fatigued-related. He found that the duration of driver's last sleep period, number of trips made over the past 24 h, and the presence of split sleep schedule (i.e., separating sleep into two or more short periods each day) are significantly different between these two groups. Since 1938, FMCSA has enforced a series of safety rules on Hours-of-Service (HOS) to ensure commercial motor vehicle drivers get enough rest and to prevent driver fatigue and the crash risk associated with it. The safety rules for property-carrying Commercial Motor Vehicle (CMV) drivers include four basic terms related to off-duty. Specifically, drivers can make use of: (a) 10 consecutive off-duty hours, (b) 34 or more consecutive off-duty hours, (c) sleeper berths, and (d) rest breaks to recover and get ready for the next driving task. Among these, rest breaks were not included in previous versions of safety rules for property-carrying CMVs and were added recently. Although rest breaks have gained increasing attention in recent years, two remaining fundamental questions are how many hours of off-duty time and how many rest breaks are enough to prevent driver fatigue/drowsy driving from happening?

1.2. Experimental studies about driver fatigue

Several studies have shown that lack of sleep can seriously affect truck driver's safety performance. Dinges et al. (1997) conducted an experiment consisting of 16 young drivers. These young drivers were hired to perform various driving tasks for 9 consecutive days. The first day was used as the baseline and all drivers were given adequate sleep before it. In the following seven days, all drivers were given an

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average of only 5 h of sleep per night prior to their trips. Before the last day of trip, drivers were again given enough time to rest. Based on the experimental results, Dinges et al. (1997) found that these young drivers' levels of fatigue increased immediately and significantly with sleep restriction. Some aspects of Psychomotor Vigilance Test (PVT) showed a substantial elevation after the second day of sleep restriction. Also, they found that the restriction of sleep time to 4 ~ 5 h per night caused drivers' reaction times to increase significantly within three nights. Another similar study was conducted by Van Dongen, Maislin, Mullington, and Dinges (2003) with 48 adult participants. They concluded that restricting sleep time to 4 or 6 h per day for 14 days considerably affected drivers' safety performance. On the contrary, drivers with 8 h of sleep per night for over 24 days had almost no sign of declined behavioral alertness. Belenky et al. (2003) also conducted an experiment with 66 CMV drivers. They concluded that seven days of sleep restriction caused drivers' PVT results to deteriorate. Specifically, restricting sleep to 5 or 7 h caused drivers' performance to decline at the beginning and to stabilize at a lower level during the rest of the sleep restriction period. Also, restricting sleep time to 3 h resulted in continuous decline of driving performance. On the other hand, they found that drivers with 9 h of sleep every day generally showed no sign of fatigue or impaired ability to operate vehicles during driving. It was concluded that 8 h (or longer) of sleep is enough for CMV drivers to get adequate rest. The FMCSA requires that commercial truck drivers must have a minimum of 10 h of off-duty time between their HOS. Such a requirement seems reasonable, since most truck drivers cannot fully make use of the off-duty period for sleep. They also spend their off-duty time on other activities such as dining and entertainment.

1.3. Field study of off-duty time per trip

The term off-duty time per trip was initially introduced in the first edition of HOS rules and its length has been modified several times since then. It had been set to 8 h from 1962 to 2002 and to 10 h from 2003 to 2012. The off-duty time per trip was changed back to 8 h in July 2013. Many studies have been conducted to investigate off-duty time because of its significant impact on relieving truck drivers' fatigue. It is generally agreed that lack of enough rest is a major threat to truck drivers' driving performance and safety. Arnold, Hartley, Corry, Hochstadt, Penna, and Feyer (1997) conducted a study in Australia and surveyed 1249 truck drivers and 84 management representatives. He found that 32.4% of the drivers and 48.8% of the surveyed representatives considered lack of sleep as a major contributor to fatigue-related events. The survey showed that on average 12% of the drivers had less than 4 h of sleep; 20% of them had less than 6 h of sleep; and one third had more than 8 h of sleep. The author also found that 5% of the drivers had a fatigue-related event; and 20% of the drivers who had less than 6 h of sleep accounted for 40% of the events. Mitler, Miller, Lipsitz, Walsh, and Wylie (1997) conducted a study that monitored the 24-hour electrophysiological performance of 40 commercial truck drivers from the United States and 40 commercial truck drivers from Canada who worked day, night, or irregular shifts. Their study included 400 principal sleep periods for those drivers. Mitler et al. found that the average sleep times of these drivers were 5.18 h in bed per day and 4.78 h of electrophysiologically-verified sleep per day. Crum, Morrow, Olsqard, and Roke (2001) concluded that drivers require at least 5 h of uninterrupted sleep between driving stints. They also found that 5 h are the minimum requirement not the optimal length of sleep time. Another survey conducted by Hanowski, Wierwille, and Dingus (2003) used naturalistic data and targeted at local short-haul truck drivers. They concluded that drivers involved in at-fault incidents related to fatigue typically had less self-reported sleep time (5.33 h) than drivers who were not involved in fatigue-related at-fault incidents (6.13 h). In another study, Hanowski, Hickman, Fumero, Olson, and Dingus (2007) also used naturalistic data from 82 truck drivers. They found that the average sleep time for drivers involved in critical incidents (38 critical incidents) was 5.28 h compared to 6.63 h for other drivers. Also, the average sleep time was 5.25 h for drivers involved in at-fault incidents (29 truck drivers involved in at-fault incidents) compared to 6.70 h for other drivers. On average, most drivers surveyed only had 4 to 5 h of sleep.

Lin, Jovanis, and Yang (1993) collected 1942 observations with 694 crashes from a national less-than-truckload (Barnhart & Kim, 1995) company that usually transports shipments less than 10,000 lb. They developed several logistic regression models based on the data and concluded that off-duty time has little effect on crash risk when it is greater than 9 h. If the off-duty time is less than 9 h, drivers may have a 32% higher chance of being involved in a crash. In practice, it is difficult for FMCSA to enforce the HOS rules regarding the off-duty time for truck drivers to make sure that they receive enough sleep. What often happens is that truck drivers use other ways to recover from fatigue, for instance, rest breaks during trips.

1.4. Rest breaks per trip

Truck drivers can use rest breaks to recover effectively. However, rest breaks were not included in previous versions of HOS rules. The most recent HOS rules published in December 2011 did add the following term about rest breaks: “May drive only if 8 hours or less have passed since end of driver's last off-duty period of at least 30 minutes.” The compliance date of this new requirement was July 1, 2013. The inclusion of this new requirement indicates that rest breaks are equivalently important as other methods in preventing driver fatigue. A few studies on truck driver crash risk have investigated the influence of rest breaks on driver fatigue. There is no consensus regarding the appropriate length of a rest break for truck drivers. Lin et al. (1993) found that rest breaks, particularly those taken before the sixth or seventh one during a trip, helped to lower crash risk significantly. Harris and Mackie (1972) also performed a study to investigate the effectiveness of rest breaks when taken every 3 h. They concluded that the third break's impact on reducing crash risk is insignificant. Chen, Furth, and Dulaski (2012) used a Cox regression model with time-dependent covariates to analyze the effects of rest breaks on driver fatigue. They assumed a transient effect of rest breaks that combines both their fixed and variable effects on truck drivers' crash risk. Similar to the study by Harris and Mackie (1972), Chen et al. (2012) concluded that the first and second rest breaks have a significant impact on reducing drivers' crash risk but the effect of the third rest break is limited.

1.5. The objectives of this study

Due to the significant impact of rest breaks on driver fatigue, this paper aims to analyze the effects of rest breaks on truck driver's crash risk by using the Cox proportional hazards (PH) regression model. In this research, the impacts of the total duration of rest breaks, number of rest breaks, driving time from trip start to each rest break, and the duration of each rest break are investigated. Moreover, Andersen–Gill model is used to investigate the joint effects of both off-duty time and the total duration of rest breaks.

2. Method

This research is a case–control study using Cox proportional hazards (PH) and Anderson–Gill models to analyze the truck driver safety data collected from a national truckload carrier in 2010. Different from less-than-truckload carriers (Barnhart & Kim, 1995), a truckload carrier generally contracts an entire trailer-load to a single customer who has a substantial amount of freight to be loaded into a semi-trailer or container. Case–control studies are often used in epidemiology. In a case–control study, patients with and without a certain disease are categorized as *cases* and *controls*, respectively. The levels of exposure of each group to various risk factors are then compared and used to determine the relationship between the risk factors and the disease. In the context of