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Truck Driver Sleep Patterns Influence Driving Performance

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1. Problem

Fatigued or drowsy driving has been identified as a major cause of truck crashes. A primary reason for occupational fatigue is incompatible timing of duty schedules relative to circadian rhythm and the need for sleep. Age and body mass index (BMI) are also contributing factors to fatigue. The objectives of this study included: (1) to examine truck drivers' sleep patterns in non-work periods, and (2) to evaluate the associations between sleep patterns and driving performance and risk in the immediate subsequent work period, adjusted for years of commercial truck driving experience, drivers' age, gender, and BMI.

2. Methods

This study used the Naturalistic Truck Driving Study that recorded approximately 735,000 miles of truck driving by 96 commercial truck drivers (75 long-haul and 21 line-haul truck drivers). Each driver participated in the study for approximately four weeks. A shift was defined as a non-work period followed by a work period. A total of 1,397 shifts were identified. K-mean cluster analysis was used to identify sleep patterns based on four quantitative measures: sleep duration, sleep start and end points in a non-work period, and the amount of sleep as a percentage of the non-work period. Driving performance was measured by safety-critical events (SCEs), which included crashes, near-crashes, crash-relevant conflicts, and unintentional lane deviations. Negative binomial regression was used to evaluate the association between the sleep patterns and

SCEs, adjusted for driver demographic and employment information including age, gender, BMI, and years of commercial vehicle driving experience.

4. Results

Figure 1 shows the distributions of the identified clusters with respect to the four original sleep pattern measures used in *K*-mean cluster analysis as well as the duration of non-work period. Cluster 1 had an average of 6.7 hours sleep, with sleep started in the middle of the non-work period and lasted approximately half of the non-work period. Patten 2 had an averaging of 5.8 hours sleep, with sleep started at the beginning of the non-work period and lasted on average for 44% of the non-work period. Pattern 3 had an average of 8.1 hours sleep, with sleep occupied two-thirds of the non-work period. Pattern 4 had an average of 9.3 hours sleep, with sleep occupied 93% of the non-work period.

The results of negative binomial regression model are shown in Table 1. Sleep patterns, years of commercial vehicle driving, gender, and BMI are associated with SCE risk. Sleep pattern Cluster 2 has about 1.8 and 1.6 times the SCE rate as compared to Cluster 3 and Cluster 4, indicating that a shorter sleep at the early stage of a non-work period was associated with a higher SCE risk, as compared with a longer sleep. Moreover, male drivers have an SCE rate about 2 times that of female drivers. More years of commercial vehicle driving is associated with a decrease in SCE risk, and higher BMI is associated with an increase in SCE risk.

Table 1. Selected characteristics by sleep cluster

Cluster	Average sleep duration	Amount of sleep as % of non-work period	Average sleep start point (%)	% with any sleep in 1-5 am	SCEs per 100 hours driven
1	**6.7 h**	**53**	**41**	**86**	**16.4**
2	**5.6 h**	**44**	**10**	**35**	**21.8**
3	**8.1 h**	**68**	**19**	**83**	**13.4**
4	**9.3 h**	**93**	**5**	**89**	**13.7**

Table 2 SCE rate ratios by clusters and demographics

	Rate Ratio	95% LCL	95% UCL	*p*-value
Cluster 1 vs. 4	1.25	0.90	1.73	0.187
Cluster 2 vs. 4	1.62	1.01	2.59	0.044*
Cluster 3 vs. 4	0.91	0.70	1.18	0.465
Cluster 1 vs. 3	1.38	0.99	1.90	0.054
Cluster 2 vs. 3	1.79	1.12	2.84	0.014*
Cluster 1 vs. 2	0.77	0.47	1.27	0.309
Years of Commercial Vehicle Driving	0.98	0.97	0.99	0.010*
Age	1.00	0.99	1.01	0.644
Gender (M vs. F)	1.98	1.21	3.26	0.007*
BMI	1.03	1.01	1.04	0.005*

* indicates the p-value <0.05.

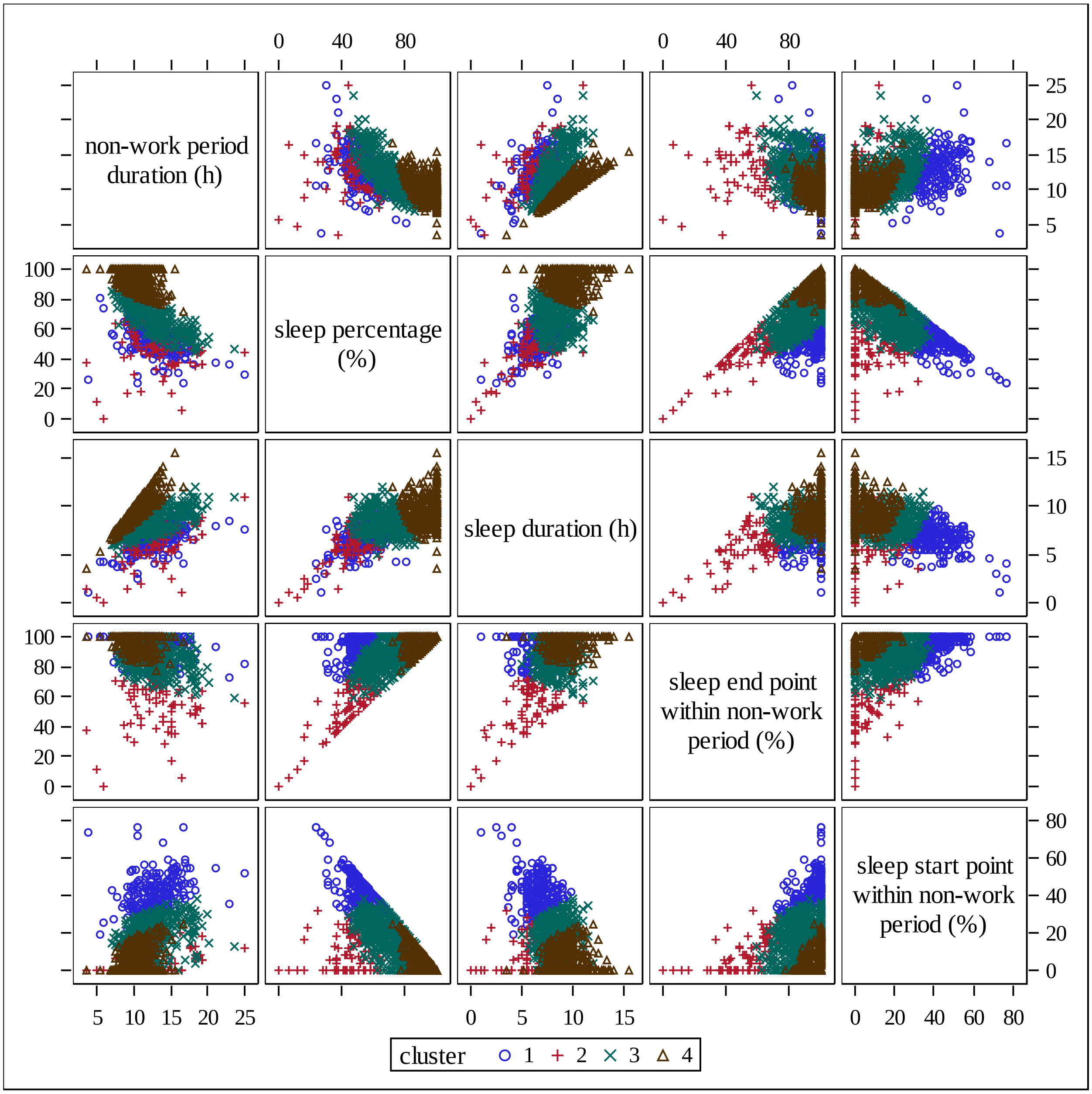

Figure 1. Distribution of sleep pattern clusters

5. Discussion

Four distinctive sleep pattern clusters in a work shift were identified among commercial truck drivers. The shifts with shorter sleep in the early stage of the non-work period (Cluster 2) had a higher SCE risk than the shifts with a longer-duration sleep that occupied the majority of non-work periods (Cluster 3 and 4). When the sleep duration was short, sleep in the late stage of non-work period (Cluster 1) might be more beneficial for driving performance than sleep in the early stage (Cluster 2). Shifts with more sleep time between 1 and 5 a.m. (Cluster 1, 3, 4) had a lower driving risk and better driving performance than shifts with less sleep time between 1 and 5 a.m. (Cluster 2). Moreover, the study revealed that increased years of commercial vehicle driving experience were associated with a decreased SCE risk, and increased BMI was associated with an increased SCE risk. This result is agreed with previous studies which showed that there is a link between obesity and fatigue among commercial truck drivers.

Limitations of our analysis include the relatively small samples of study participants, workday shifts; thus, confidence intervals were relatively wide, even with the combination of crashes, near-crashes, crash-relevant conflicts, and unintentional lane deviations. Another limitation is the small number of female drivers (n=5) in this study. The gender effect should be interpreted with caution due to the small sample size of female drivers. The self-reported daily activity registry in this study were subject to human error and recall bias.

5. Summary

Findings from this study have implications on driver training and crash prevention, for example, educating drivers on the safety benefits of adequate sleep (drivers should aim for at least 7 hours sleep daily), sleep in the time period of 1 a.m. to 5 a.m., and arranging sleep in the later stage of non-working period if possible. NIOSH has recommended useful sleep tips for truck drivers. Company safety policies can consider incorporating health and wellness programs addressing truck driver obesity, along with other countermeasures to address behind-the-wheel drowsiness such as hours-of-service compliance and the North American Fatigue Management Program (www.nafmp.com).

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