Report #17-UI-046

NSTSCE

National Surface Transportation Safety Center for Excellence

Evaluating the Sleeper Berth Provision

Investigating Usage Characteristics and Safety-Critical Event Involvement

Susan A. Soccolich • Myra Blanco • Richard J. Hanowski

Submitted: July 20, 2015

Technology
Impairment
Mobility
Infrastructure

Housed at the Virginia Tech Transportation Institute
3500 Transportation Research Plaza • Blacksburg, Virginia 24061

ACKNOWLEDGMENTS

The authors of this report would like to acknowledge the support of the stakeholders of the National Surface Transportation Safety Center for Excellence (NSTSCE): Tom Dingus from the Virginia Tech Transportation Institute, John Capp from General Motors Corporation, Lincoln Cobb from the Federal Highway Administration, Chris Hayes from Travelers Insurance, Martin Walker from the Federal Motor Carrier Safety Administration, and Cathy McGhee from the Virginia Department of Transportation and the Virginia Center for Transportation Innovation and Research.

The NSTSCE stakeholders have jointly funded this research for the purpose of developing and disseminating advanced transportation safety techniques and innovations.

EXECUTIVE SUMMARY

Hours-of-service (HOS) regulations control the maximum daily drive time, workday hours, and work week (period) hours for commercial motor vehicle (CMV) drivers. The regulations also include periods of off-duty time that drivers must take before beginning a work shift, referred to as shift-restart methods in this study. In the 2005 regulations, the shift-restart methods included taking at least 10 consecutive hours off duty or in the sleeper berth (10+ hour restart), taking at least 34 consecutive hours off duty or in the sleeper berth (34+ hour restart), and a sleeper berth provision (SBP). The SBP requires one period of at least 8 (but less than 10) consecutive hours spent in the sleeper berth plus a period of at least 2 (but less than 10) consecutive hours spent in the sleeper berth, off duty but not in the sleeper berth, or a combination of off-duty time spent in and out of the sleeper berth. The purpose of this project was to examine the usage of shift-restart methods and the relationship between shift-restart methods and driver safety performance in a naturalistically collected driving data set.

METHODS

The data used for this study were collected by the Virginia Tech Transportation Institute (VTTI) in the Naturalistic Truck Driving Study (NTDS) and developed into a hybrid data set of naturalistically collected video data and activity register data that accurately detail the participating CMV drivers' driving and non-driving activities.[7] With the activity register data, researchers determined which restart method drivers used before beginning a new work shift: 10+ hour restart, 34+ hour restart, or the SBP.

RESULTS

The proportion of shifts preceded by SBP breaks was significantly higher for drivers who reported taking medications regularly versus those who did not and also for drivers with longer average delivery distances. The number of years of CMV driving experience had a significant inverse relationship with the proportion of total shifts with SBP breaks. A mixed-effect negative binomial model with a logarithmic link function was used to model safety-critical event (SCE) rate at the shift level, controlling for the driver. The SCE rates in shifts following an SBP break were found not to be statistically different from those in shifts following 10+ hour or 34+ hour restart breaks. Odds ratios were also used to assess the risks associated with each of the three shift-restart methods. The 10+ hour restart and 34+ hour restart methods were found not to be significantly different. However, both the 10+ hour restart and 34+ hour restart methods were associated with significantly higher risk than the SBP.

DISCUSSION

This project serves to enhance the understanding of the current HOS regulations and the impact that these regulations have on drivers, a topic of significant concern in the CMV community. Drivers have different preferred break usage patterns. The use of the SBP in the current study does not appear to be associated with a decrement in safety performance. Future efforts should look into how the usage of shift-restart methods has changed under the new regulations, which went into effect on July 1, 2013, and modified the driving limits, on-duty time limits, and rest break requirements.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	analysis of variance
CI	confidence interval
CMV	commercial motor vehicle
DAS	data acquisition system
DDWS FOT	Drowsy Driving Warning System Field Operational Test
DF	degrees of freedom
FAA	Federal Aviation Administration
FMCSA	Federal Motor Carrier Safety Administration
HOS	hours of service
LCL	lower confidence limit
L/SH	local/short haul
LTCCS	Large Truck Crash Causation Study
LTL	less-than-truckload
MS	mean square
NASA	National Aeronautics and Space Administration
NB	negative binomial
NSF	National Sleep Foundation
NTDS	Naturalistic Truck Driving Study
OR	odds ratio
SBP	sleeper berth provision
SCE	safety-critical event
SE	standard error
SS	sum of squares
TL	truckload
UCL	upper confidence limit
U.S. DOT	United States Department of Transportation
VMT	vehicle miles traveled
VTTI	Virginia Tech Transportation Institute

CHAPTER 1. INTRODUCTION

In 1940, the United States federal government issued the first set of hours-of-service (HOS) regulations for commercial motor vehicle (CMV) drivers. These regulations controlled the maximum daily drive time, workday hours, and work-week hours for CMV drivers. The regulations also included a sleeper berth provision (SBP), which allowed a driver to use the sleeper berth to split the required break or off-duty time into multiple, smaller periods. Before the 2013 revision, the HOS regulations were revised in 1962, 2003, and 2005, and each revision modified the SBP. In the 2005 HOS regulations, drivers could drive up to 11 hours in a 14-hour working window. After 11 hours of driving or after the 14-hour working window had expired, drivers could remain on duty and continue to do non-driving work.

Drivers could restart a duty shift by splitting the required 10 consecutive off-duty hours into a period of at least 8 (but less than 10) consecutive hours spent in the sleeper berth and a period of at least 2 (but less than 10) consecutive hours in the sleeper berth, off duty but not in the sleeper berth, or a combination of off-duty time spent in and out of the sleeper berth. Hours in the sleeper berth that do not contribute to the restart of a shift are considered workday hours and count toward the working-hour window during which drivers can operate the CMV. Under the 2005 HOS regulations, other ways to restart a duty shift included taking at least 10 consecutive hours off duty or in the sleeper berth or taking at least 34 consecutive hours off duty or in the sleeper berth; in this study, these methods are referred to as the 10+ hour restart and the 34+ hour restart, respectively. Even though drivers taking a 34+ hour restart have also met the 10+ hour restart requirement, the breaks are considered separate as other HOS regulations are affected by the longer restart break and drivers may have purposely taken an extended break over the 10+ hour restart. After a legal restart break was taken, drivers could begin a new duty shift and drive up to 11 hours in a 14-hour window. The naturalistic driving data used in this study were collected under the 2005 HOS rules. Thus, this report only examines the usage patterns and safety implications of the 2005 HOS rules.

Researchers have come to mixed conclusions regarding the safety implications of short, more-frequent breaks during driving. Under the 2005 HOS regulations, CMV drivers could drive up to 11 hours in a 14-hour period. Drivers were not required to take a break from driving during their workday and were allowed to perform non-driving work beyond the 14-hour period. These long hours, along with variable schedules and monotonous driving, can lead to driver drowsiness. Some feel that the SBP provides drivers with the flexibility to adjust their schedule in response to changes in their day (e.g., weather, traffic, and drowsiness).(1) Sleep quality deviates only slightly between sleeper-berth sleep and home sleep.(2) In a laboratory study comparing the effects of consolidated night sleep, consolidated day sleep, and split sleep in a sample of men (not CMV drivers), no significant differences were found among the three sleep conditions in terms of lane deviation, speed, and braking performance in a driving simulator.(3) However, other researchers have found the SBP to be associated with unsafe or fatigued driving. Drivers who used the sleeper berth to accumulate break time reported more fatigue than drivers not using the sleeper berth to accumulate break time.(4) Drivers who used the sleeper berth to accumulate break time were at significantly higher risks for involvement in fatal accidents compared to drivers not using the sleeper berth to accumulate break time.(5)

During the Blanco et al. study, researchers created a hybrid data set of video data and activity register data detailing participating CMV drivers' driving and non-driving activities during their time in the Naturalistic Truck Driving Study (NTDS).[6,7] The study was carried out under the 2005 HOS regulations. The hybrid data set provided a unique opportunity to analyze driving hours, working hours, and breaks from driving. The research focused on analyzing the break methods and their relationship with CMV driver safety and work schedules. This study differed from past studies due to the unique nature of its hybrid data set and the analysis of the (2005) SBP regulations.

Using the hybrid data set, researchers determined how drivers restarted a duty shift. The methods included the SBP, 10+ hour restart, and 34+ hour restart. Changes in use of the shift-restart methods were assessed over several driver characteristics (e.g., driver demographic, health, and sleep variables) and work characteristics (e.g., drive hours, work hours, and average mileage to delivery points). The current study also assessed whether safety-critical event (SCE) occurrence varies as a function of SBP use and how risk changes in shifts following each of the three shift-restart methods.

CHAPTER 2. METHODS AND ANALYSIS APPROACH

The data used for this study were collected in the Virginia Tech Transportation Institute's (VTTI's) NTDS and developed into a hybrid data set of naturalistically collected video data and activity register data that accurately details the driving and non-driving activities of participating CMV drivers.[6,7]

DATA COLLECTION METHODS

Data were collected during the NTDS from November 2005 to March 2007. A total of 100 drivers participated in the NTDS, although three drivers were removed due to missing data. Of the 97 remaining drivers, 96 provided demographic information. These drivers had an average age of 44.5 years (range 21 to 73 years) and included 91 males and 5 females. The drivers reported an average of 9.1 years of experience (range 4 weeks to 54 years). The drivers were from four different fleet companies: two based in Virginia and two in North Carolina. Drivers traveled an average of 305.8 miles (standard error [SE] = 20.3) per delivery from their pick-up location. The companies and drivers in this study were volunteers and, as with any study that uses volunteers, the companies and drivers may not be representative of the general population of CMV drivers.

The data were collected using a naturalistic approach; i.e., data were collected continuously as participants drove the instrumented company trucks during their normal revenue-producing runs. In this study, once a driver had completed his/her role, a different participating driver was assigned to the instrumented truck. Each driver drove an instrumented truck for approximately four weeks. Each instrumented truck was equipped with a data acquisition system (DAS) comprising a computer, external hard drive, sensors, vehicle network, incident box, and five video cameras. The sensors, which were used to measure driver performance, included front radar-based Eaton VORAD, a Global Positioning System (GPS), a lane-tracking system, a yaw rate sensor, and an X/Y accelerometer. The five video cameras recorded the driver's face, steering wheel, and three views on the outside of the truck (Figure 1). More information on the DAS and sensors can be found in Blanco et al., 2011.[7]

Figure 1. Photo. Five camera images multiplexed into a single image (driver is a VTTI employee and not a study participant).

The study used SCEs and baselines to evaluate driver performance. Potential SCEs and baselines were identified using a software program that searches the naturalistic data for sensor values characteristic of unsafe or safe driving. Researchers reviewed the triggered video and sensor data to verify the occurrence of an SCE or a baseline. The SCEs included crashes, near-crashes, crash-relevant conflicts, and unintentional lane deviations, defined as follows:

- **Crash**: Any contact with a moving or fixed object at any speed, including another vehicle, roadside barrier, object on or off of the roadway, pedestrian, pedalcyclist, or animal.

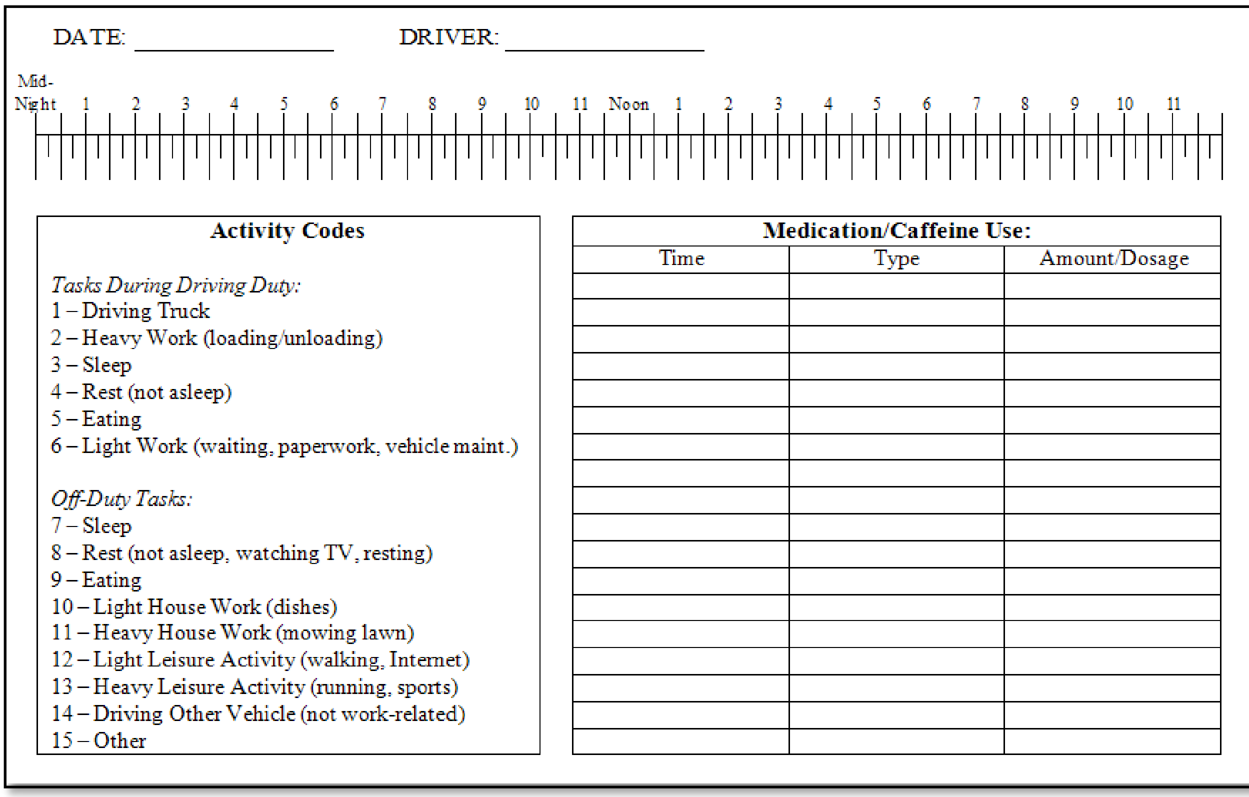
- **Near-crash**: Any circumstance requiring a rapid, evasive maneuver (e.g., hard braking or steering) by the subject vehicle or any other vehicle, pedestrian, pedalcyclist, or animal in order to avoid a crash.

- **Crash-relevant conflict**: Any circumstance requiring a crash-avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, pedalcyclist, or animal that is less severe than a rapid evasive maneuver (as defined above) but greater in severity than a normal maneuver. A crash-avoidance response can include braking, steering, accelerating, or any combination of control inputs.

- **Unintentional lane deviation**: Any circumstance where the subject vehicle crosses over a solid lane line (e.g., onto the shoulder) where no hazard (e.g., guardrail, ditch, vehicle) is present.

The baseline epochs used in this study were originally identified and reduced in Olson et al., who collected 20,000 baseline epochs from drivers in the NTDS and Drowsy Driver Warning System Field Operational Test (DDWS FOT) studies.(6,8,9) The total driving time over 15 mph was determined across all drivers. Each individual driver's proportion of baseline epochs was equal to their proportion of total driving time over 15 mph. Each driver's proportion of baseline epochs was then multiplied by 20,000 to obtain the number of baseline epochs to sample from that driver. Baseline epochs of a minimum speed of 15 mph and with no SCEs were then randomly sampled from the driver's available data.

Participants in the NTDS were asked to detail their daily activities in an activity register for the entire four weeks of participation in the study.[5] One activity register page corresponded to one date (one midnight-to-midnight 24-hour period). Figure 2 shows a sample page of the activity register. Drivers used six activity codes to denote activities during duty and nine for off-duty activities. Table 1 lists each activity code, its duty period classification, and its description.


DATE: ________________ DRIVER: ________________

Mid-Night 1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11

Activity Codes

Tasks During Driving Duty:
1 – Driving Truck
2 – Heavy Work (loading/unloading)
3 – Sleep
4 – Rest (not asleep)
5 – Eating
6 – Light Work (waiting, paperwork, vehicle maint.)

Off-Duty Tasks:
7 – Sleep
8 – Rest (not asleep, watching TV, resting)
9 – Eating
10 – Light House Work (dishes)
11 – Heavy House Work (mowing lawn)
12 – Light Leisure Activity (walking, Internet)
13 – Heavy Leisure Activity (running, sports)
14 – Driving Other Vehicle (not work-related)
15 – Other

Medication/Caffeine Use:

Time	Type	Amount/Dosage

Figure 2. Illustration. Daily activity register sheet used to record activities.

Table 1. Activity code descriptions.

Activity Code	Duty Period	Description
1	Tasks During Driving Duty	Driving Truck
2	Tasks During Driving Duty	Heavy Work (Loading/Unloading)
3	Tasks During Driving Duty	Sleep
4	Tasks During Driving Duty	Rest
5	Tasks During Driving Duty	Eating
6	Tasks During Driving Duty	Light Work
7	Off-Duty Tasks	Sleep

Activity Code	Duty Period	Description
8	Off-Duty Tasks	Rest (Not Asleep, Watching TV, Resting)
9	Off-Duty Tasks	Eating
10	Off-Duty Tasks	Light House Work (Dishes)
11	Off-Duty Tasks	Heavy House Work (Mowing Lawn)
12	Off-Duty Tasks	Light Leisure Activity (Walking, Internet)
13	Off-Duty Tasks	Heavy Leisure Activity (Running, Sports)
14	Off-Duty Tasks	Driving Other Vehicle (Not Work-Related)
15	Off-Duty Tasks	Other

Participants indicated their activities on the 24-hour timeline near the top of the daily activity register. Participants chose one of the 15 activity codes and marked the beginning and end of the activity on the timeline. Figure 3 displays an example of a completed activity register timeline. Three drivers had missing activity register data and were not included in the analyses.

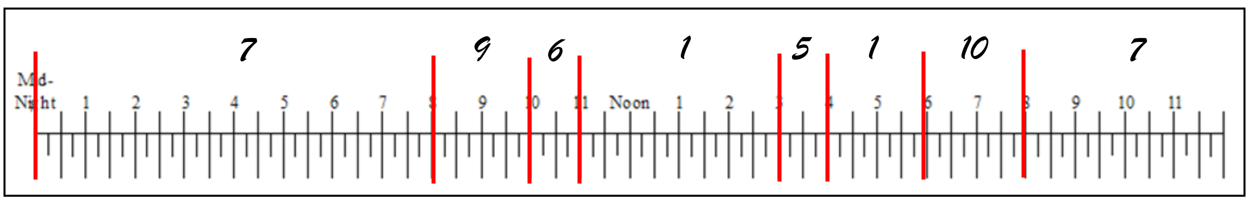


Figure 3. Illustration. Timeline with activity codes.

As part of their participation in the study, drivers also completed various questionnaires. The questionnaires collected information on their demographic characteristics, health conditions and habits, and sleep hygiene. The complete list of questionnaires can be found in Blanco et al.[6] Of the 97 drivers with naturalistic and activity register data, 96 drivers provided demographic information.

HYBRID DATA SET

Blanco et al. created a thoroughly verified, hybrid data set of the NTDS naturalistically collected video data and activity register data.[7] A general overview of the steps taken to develop the hybrid data set are given here.

The video data were collected when the truck's ignition was initiated. The video data along with speed information could then be used to verify or update the time of driving activities marked by the driver in the activity register. By definition, baselines and SCEs must occur during driving; thus, the activity registers had to be adjusted to reflect that a baseline or SCE occurred only during driving. Blanco et al. (2011) adjusted the driving periods in the activity register to ensure that all SCEs occurred during marked driving periods.[7] The current study followed the same process for the previously selected baselines.

Additional activity codes were created and used by the researchers to indicate time periods left blank in the activity register. These specific activity codes conveyed the period was left blank, the activity types on either side of the blank period, and the duration of the blank period. If video data indicated driving during time periods left blank by the participant, the activity register was adjusted to reflect driving activities. After these adjustments, the hybrid data reflected verified driving activities in the activity registers of all participants.

The hybrid data set was then used to identify *shift-restart breaks*, which, in this study, refer to breaks that allowed drivers to start or extend a new driving window under the 2005 HOS regulations. Table 2 details the three types of shift-restart methods analyzed in this study. Shift-restart breaks were identified by looking for time periods in the hybrid data set that met the definition of one of the three shift-restart methods (due to the activity codes and duration of the activities recorded in the hybrid data set). The terms "shift-restart break," "shift-restart method," and the names of the shift-restart methods were created by the researchers in this study to express intricate aspects of the HOS regulations. These terms are not found in the 2005 HOS regulations.

Table 2. Definitions and schedule implications of shift-restart methods.

Shift-Restart Method	Definition	Effect on Schedule	Activity Codes
10+ hour	Driver takes at least 10 consecutive hours off duty or in the sleeper berth.	Driver restarts driving clock and may now drive a maximum of 11 hours in a 14-hour window.	3–5, 7–15, and blank periods bordered on both sides by 3–5 or 7–15
34+ hour	Driver takes at least 34 consecutive hours off duty or in the sleeper berth.	Driver restarts driving clock and may now drive a maximum of 11 hours in a 14-hour window. Driver restarts weekly driving clock and may now drive a maximum of 60 hours in 7 days or 70 hours in 8 days.	3–5, 7–15, and blank periods bordered on both sides by 3–5 or 7–15
SBP	Driver takes two distinct breaks: one of at least 8 (but less than 10) consecutive hours spent in the sleeper berth and one of at least 2 (but less than 10) consecutive hours spent in the sleeper berth, off duty but not in the sleeper berth, or a combination of off-duty time spent in and out of the sleeper berth.	Driver restarts driving clock and may now drive a maximum of 11 hours in a 14-hour window. Driver restarts weekly driving clock and may now drive a maximum of 60 hours in 7 days or 70 hours in 8 days.	3–5, 7–15, and blank periods bordered on both sides by 3–5 or 7–15

A shift was defined as the activities that occurred between two shift-restart breaks. The driving time during each shift was calculated by summing the driving period durations (marked in the activity register as activity code 1 that occurred during the shift. Work time during each shift consisted of all tasks that were not part of a shift-restart break. Thus, work time could include driving (activity code 1), non-driving work (activity codes 2 and 6), on-duty rest (activity codes 3, 4, and 5), off-duty rest (activity codes 7–15), and blank periods.

ANALYSIS APPROACH

Researchers used the hybrid data set to calculate driving hours, working hours, shift-restart method (10+ hour restart, 34+ hour restart, or SBP), and the numbers of SCEs and baselines that occurred during each shift.

Driver Characteristics and Sleeper Berth Provision Use

To analyze the relationships between SBP use and various driver characteristics, the proportion of shifts preceded by an SBP break was calculated for each driver. Driver characteristics that were continuous variables were evaluated individually with linear regression models. Driver characteristics that were categorical variables were evaluated individually using analysis of variance (ANOVA) for characteristics with more than two levels, a *t* test for characteristics with two levels, and the non-parametric Kruskal-Wallis test for characteristics that did not meet ANOVA assumptions. Driver characteristics included demographic, health, and sleep hygiene variables.

Table 3. Driver characteristic variables with analytic approach.

Driver Characteristic Variables	Data Type	Analytic Approach
Age	Continuous	Linear regression
CMV Driving Experience	Continuous	Spearman rank-order correlation
Body Build	Categorical	ANOVA
History of Anxiety	Categorical (Yes/No)	Kruskal-Wallis test
History of Arthritis	Categorical (Yes/No)	Kruskal-Wallis test
History of Depression	Categorical (Yes/No)	Kruskal-Wallis test
History of Diabetes	Categorical (Yes/No)	Kruskal-Wallis test
History of Dizziness, Vertigo, or Other Balance Disorders	Categorical (Yes/No)	Kruskal-Wallis test
History of Head Injury	Categorical (Yes/No)	Kruskal-Wallis test
History of High Blood Pressure	Categorical (Yes/No)	Kruskal-Wallis test
History of Inner Ear Problems	Categorical (Yes/No)	Kruskal-Wallis test
History of Migraine or Tension Headaches	Categorical (Yes/No)	Kruskal-Wallis test
History of Respiratory Disorders	Categorical (Yes/No)	Kruskal-Wallis test
Currently Taking Medications	Categorical (Yes/No)	Two sample *t*-test
Wears Contacts	Categorical (Yes/No)	Kruskal-Wallis test
Caffeinated Beverage Consumption	Categorical (Yes/No)	Kruskal-Wallis test
Usually Take Nap Between Major Sleep periods	Categorical (Yes/No)	Kruskal-Wallis test
Keeps a Fairly Regular Sleep Schedule	Categorical (Yes/No)	Kruskal-Wallis test

Driver Characteristic Variables	Data Type	Analytic Approach
History of Auto-Immune Disorders	Categorical (Yes/No)	Not analyzed with inferential tests as frequency counts for one or more responses were too low
History of Brain Tumor	Categorical (Yes/No)	
History of Chronic Fatigue Syndrome	Categorical (Yes/No)	
History of Chronic Stress	Categorical (Yes/No)	
History of Epileptic Seizures	Categorical (Yes/No)	
History of Heart Arrhythmias	Categorical (Yes/No)	
History of Motion Sickness	Categorical (Yes/No)	
History of Other Psychiatric Disorders	Categorical (Yes/No)	
History of Strokes	Categorical (Yes/No)	
Diagnosed with or Suffer from Narcolepsy	Categorical (Yes/No)	
Diagnosed with or Suffer from Sleep Apnea	Categorical (Yes/No)	
Diagnosed with or Suffer from Periodic Limb Movement	Categorical (Yes/No)	
Diagnosed with or Suffer from Restless Leg Syndrome	Categorical (Yes/No)	
Diagnosed with or Suffer from Insomnia	Categorical (Yes/No)	

Work Characteristics and Shift-Restart Method

The three shift-restart methods were tested with ANOVA and follow-up Tukey's tests for significant differences in total drive hours and total work hours per shift preceding and following the break. ANOVA was used to compare the drivers' proportions of shifts preceded by an SBP break among the different classifications of driver mileage to delivery (short, medium, and long).

Risk and Shift-Restart Method

If the SBP is truly associated with inadequate rest, drivers may be at increased risk for drowsy driving in the shift following an SBP break, and safe driving behaviors could be compromised. Differences in safety associated with the three shift-restart methods were assessed using a mixed-effect negative binomial (NB) model and odds ratios (ORs). A mixed-effect NB model with a logarithmic link function was used to model SCE rate at the shift level. The NB model permits the assumptions that the number of SCEs in a shift was generated by a stochastic (or random) process, and that the expected SCE rate is a function of various predictors. The predictor included in the model was an indicator variable for the SBP shift-restart method. If a shift was preceded by an SBP shift-restart break, the SBP indicator variable was marked "1"; if a shift was preceded by a 10+ hour or 34+ hour shift-restart break, the SBP indicator variable was marked "0." The mixed-effect NB model was able to control for individual drivers across shifts by using a driver-specific random intercept.

The shift-restart methods were further compared using ORs under the assumption that SCEs were rare occurrences. ORs were used to calculate the risks associated with the three shift-restart methods by comparing the total SCEs and baselines in the shifts following each shift-restart method for two shift-restart methods at a time. To determine if a shift-restart method is related to SCE involvement, a contingency table, such as the example shown in Table 4, was created and analyzed using an OR and the corresponding 95% confidence interval (CI). The SCE risk associated with a shift-restart method was calculated by comparing the shift-restart method to each of the other shift-restart methods in separate OR calculations. The rows in Table 4 (Shift-Restart Method A, Shift-Restart Method B) represent the format of this analysis.

Table 4. Example of a contingency table for shift-restart method comparison.

Variable	SCEs	Baselines	Total
Shift-Restart Method A	n_{11}	n_{12}	$n_{1.}$
Shift-Restart Method B	n_{21}	n_{22}	$n_{2.}$
Total	$n_{.1}$	$n_{.2}$	$n_{..}$

The formula for calculating the OR is the cross product[10] $(n_{11}*n_{22}) / (n_{12}*n_{21})$, where:

- n_{11} is the number of SCEs following Shift-Restart Method A;
- n_{12} is the number of baselines following Shift-Restart Method A;
- n_{21} is the number of SCEs following Shift-Restart Method B;
- n_{22} is the number of baselines following Shift-Restart Method B.

The CI formula is[11] $OR \times e^{\pm z*SE_{OR}}$, where *e* is a constant and the base of the natural logarithm, *OR* is the odds ratio, *z* is the z-score value corresponding to the chosen alpha (1.96 for a 95% CI), and *SE* is the standard error of the natural logarithm of the OR.

An OR is considered statistically significant if the CI does not include 1.0. If the OR for the contingency table is significant (CI does not include 1) and greater than 1.0, Shift-Restart Method A is associated with significantly greater odds of involvement in an SCE compared to Shift-Restart Method B. If the OR for the contingency table is significant and less than 1.0, Shift-Restart Method B is associated with statistically significant greater odds of involvement in an SCE compared to Shift-Restart Method A. If the OR is equal to 1.0, or if the CI includes 1.0, the odds of involvement in an SCE for Shift-Restart Methods A and B are not statistically different.

CHAPTER 3. RESULTS

DRIVER CHARACTERISTICS AND SLEEPER BERTH PROVISION USE

Researchers tested how SBP-use proportions changed with various demographic, health, and sleep factors. The factors found to have significant relationships with SBP use included years of CMV driving experience, reported arthritis, and whether the driver was currently taking medications on a regular basis. Figure 4 plots years of CMV driving experience against the proportion of shifts preceded by an SBP break. The non-linear relationship was tested using the Spearman rank-order correlation, and a significant inverse relationship was found ($\rho = -0.3811$, $p = 0.0001$).

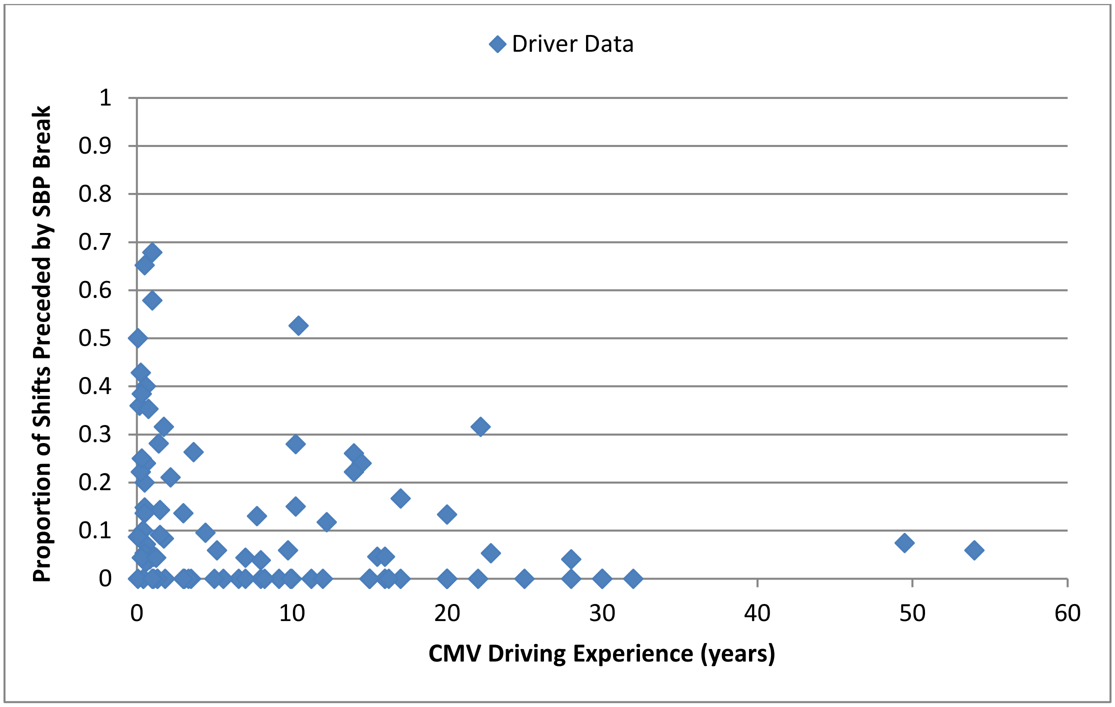


Figure 4. Graph. Scatter plot of years of CMV driving experience vs. proportion of shifts preceded by an SBP break.

Of the 96 drivers who provided medical information, 14 reported having arthritis, and 81 reported not having arthritis (one driver did not answer). The average proportion of shifts preceded by an SBP break was 0.05 (*SE* = 0.03) for those with arthritis and 0.12 (*SE* = 0.02) for those without arthritis. A Kruskal-Wallis test found the two groups had significantly different average proportions of SBP precedence ($\chi^2 = 4.0553$, $p = 0.0440$; Table 5). Five drivers reported having dizziness, vertigo, or another balance disorder, and 90 drivers reported the absence of these conditions. Drivers reporting dizziness, vertigo, or another balance disorder did not have any shifts preceded by an SBP break. The average proportion of shifts preceded by an SBP break for those without dizziness, vertigo, or another balance disorder was 0.12 (*SE* = 0.16). Table 5 lists the Kruskal-Wallis test results, which indicated that the two groups had significantly different average proportions of SBP use ($\chi^2 = 5.6759$, $p = 0.0172$).

Table 5. Health conditions analyzed with the Kruskal-Wallis non-parametric test.

Health Condition	Kruskal-Wallis χ^2	*p*
Arthritis	4.0553	0.0440
Dizziness, vertigo, or other balance disorder	5.6759	0.0172

Of the 96 drivers who provided medical information, 32 reported they took medications regularly, and 63 reported that they did not (one driver did not answer). The average proportion of shifts preceded by an SBP break was 0.05 ($SE = 0.01$) for those who took medications regularly and 0.15 ($SE = 0.02$) for those who did not take medications regularly. Assuming unequal variances, a t test indicated that the two groups had significantly different average proportions of SBP precedence ($t = -2.56$, $p = 0.0119$).

The appendix reports demographic, health, and sleep factors with very few observations or that do not have a significant relationship with SBP precedence.

WORK CHARACTERISTICS AND SHIFT-RESTART METHOD

The work characteristics tested for relationships with shift-restart method included the categorical variable “driver classification,” which was based on the average miles traveled per delivery, and two continuous variables: shift driving hours and working hours. Drivers were classified as short, medium, or long based on their average delivery mileage from home base. Each driver had a list of delivery locations. The average delivery mileage was calculated by finding the distance from their home base to each of their possible delivery locations, divided by the number of their possible delivery locations. The classifications are defined in Table 6.

Table 6. Classification of drivers based on average miles traveled per delivery.

Classification	Range of Average Miles	Number of Drivers in Classification
Short	Up to 100 miles	11
Medium	Between 100 and 500 miles	56
Long	More than 500 miles	21

Figure 5 compares the shift-restart methods used by short-, medium-, and long-mileage drivers. On average, long drivers used the SBP before 15.3% (proportion = 0.1535, $SE = 0.0383$) of their shifts, medium drivers used the SBP before 10.0% (proportion = 0.1001, $SE = 0.0176$) of their shifts, and short drivers used the SBP before 0.8% (proportion = 0.0084, $SE = 0.0057$) of their shifts.

Figure 5. Chart. Average proportions of shift-restart method used by short, medium, and long drivers.

ANOVA was used to test the average proportion of shifts preceded by an SBP break for significant differences across driver classifications. The ANOVA results indicated that the three driver classifications had significantly different proportions of SBP precedence ($F = 4.10$, $p = 0.0199$). Post hoc Tukey's tests indicated that long and short drivers had significantly different proportions of SBP precedence. Table 7 shows the results of the analysis.

Table 7. Results of Tukey's tests comparing the proportions of SBP precedence for different driver classifications.

Driver Classification Comparison	Difference Between Means	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Significant
Long vs. Medium	0.0543	-0.0297	0.1365	
Long vs. Short	0.1451	0.0242	0.2660	*
Medium vs. Short	0.0917	-0.0155	0.1988	

The three shift-restart methods were tested using ANOVA and post hoc Tukey's tests for significant differences in total drive hours and total work hours per shift preceding and following the break. Table 8 shows the average drive hours per shift preceding and following the break for all three shift-restart methods. Shifts preceding a 34+ hour break had, on average, the lowest drive time (7.56 hours). Shifts preceding an SBP break had, on average, the highest drive time (8.11 hours). Shifts following a break showed a similar pattern: shifts following a 34+ hour break had the lowest average drive time (6.96 hours), and shifts following an SBP break had the highest average drive time (7.90 hours).

Table 8. Average drive hours preceding and following each shift-restart method.

Shift-Restart Method	*N*	Average Drive Hours Preceding the Break	Average Drive Hours Following the Break
10+ hour	1,227	7.57	7.62
34+ hour	253	7.56	6.96
SBP	183	8.11	7.90

ANOVA was used to test the shift-restart methods for significant differences in the drive time of the preceding shift. Table 9 lists the results of the ANOVA. The ANOVA indicated at least one significant difference ($p = 0.0270$), and post hoc Tukey's tests indicated that the average drive time in the shift preceding an SBP break was significantly different from the average drive time in the shift preceding a 10+ hour break. All other pairwise comparisons were not significant. Table 10 lists the post hoc test results. Significant comparisons have confidence intervals that did not include 0 and are indicated with an asterisk (*).

Table 9. ANOVA results for drive hours preceding shift-restart break.

Source	df	SS	MS	*F*	*p*
Model	2	47.3815	23.6907	3.62	0.0270
Error	1,660	10,867.8473	6.5469		
Corrected Total	1,662	10,915.2288			

Table 10. Post hoc Tukey's tests for drive hours preceding shift-restart break.

Shift-Restart Method Comparison	Difference Between Means	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Significant
SBP vs. 10+ hour	0.5379	0.0623	1.0135	*
SBP vs. 34+ hour	0.5461	-0.0364	1.1285	
10+ hour vs. 34+ hour	0.0082	-0.4063	0.4226	

ANOVA and post hoc Tukey's tests were also used to test for significant differences in the drive time following the shift-restart methods. The ANOVA results (Table 11) indicated at least one significant difference ($p < 0.0001$). The post hoc tests showed that the average drive time after the SBP shift-restart method was significantly different from that after the 34+ hour method, but was not significantly different from the average drive time after the 10+ hour method. The 10+ hour and 34+ hour shift-restart methods were also found to have significantly different drive times in the shift following the break. Table 12 lists the post hoc test results. Significant comparisons have confidence intervals that did not include 0 and are indicated with an asterisk (*).

Table 11. ANOVA results for drive hours following shift-restart break.

Source	df	SS	MS	*F*	*p*
Model	2	125.9350	62.9675	9.28	<0.0001
Error	1,773	11,755.6595	6.7834		
Corrected Total	1,735	11,881.5944			

Table 12. Post hoc Tukey's tests for drive hours following shift-restart break.

Shift-Restart Method Comparison	Difference Between Means	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Significant
SBP vs. 10+ hour	0.2771	-0.1908	0.7450	
SBP vs. 34+ hour	0.9412	0.3696	1.5128	*
10+ hour vs. 34+ hour	0.6641	0.2558	1.0724	*

Table 13 shows the average work hours (which include both non-driving work hours and driving hours) per shift preceding and following the break for all three shift-restart methods. Shifts preceding a 10+ hour break had, on average, the lowest work hours (10.84 hours). Shifts preceding an SBP break had, on average, the highest work hours (12.05 hours). When considering shifts following the break, 34+ hour breaks had the lowest average work hours (10.50 hours), and SBP breaks had the highest average work hours (12.57 hours).

Table 13. Average work hours preceding and following each shift-restart method.

Shift-Restart Method	*N*	Average Work Hours Preceding the Break	Average Work Hours Following the Break
10+ hour	1,267	10.84	10.84
34+ hour	272	10.98	10.50
SBP	197	12.05	12.57

The methods used to analyze work hours were the same as those used to analyze drive hours. ANOVA was first used to test the shift-restart methods, and post hoc Tukey's tests were conducted if the ANOVA indicated a significant result. Table 14 lists the ANOVA results for work hours preceding the shift-restart break. The ANOVA indicated at least one significant difference ($p < 0.0001$), and post hoc Tukey's tests found that the average work time preceding SBP breaks was significantly different from those preceding 10+ hour breaks and 34+ hour breaks. The 10+ hour and 34+ hour shift-restart methods were not found to have significantly different work hours in the shift preceding the break. Table 15 lists the post hoc test results. Significant comparisons have confidence intervals that did not include 0 and are indicated with an asterisk (*).

Table 14. ANOVA results for work hours preceding shift-restart break.

Source	df	SS	MS	*F*	*p*
Model	2	230.6901	115.3451	16.10	<0.0001
Error	1,660	11,896.2201	7.1664		
Corrected Total	1,662	12,126.9102			

Table 15. Post hoc Tukey's tests for work hours preceding shift-restart break.

Shift-Restart Method Comparison	Difference Between Means	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Significant
SBP vs. 10+ hour	1.2034	0.7058	1.7011	*
SBP vs. 34+ hour	1.0641	0.4547	1.6735	*
10+ hour vs. 34+ hour	-0.1393	-0.5729	0.2943	

Table 16 lists the results of the ANOVA for work hours following the shift-restart break. The ANOVA indicated at least one significant difference ($p < 0.0001$), and post hoc Tukey's tests found that the average work time following SBP breaks was significantly different from those following 10+ hour breaks and 34+ hour breaks. The 10+ hour and 34+ hour shift-restart methods were not found to have significantly different work hours in the shift following the break. Table 17 lists the post hoc test results. Significant comparisons have confidence intervals that did not include 0 and are indicated with an asterisk (*).

Table 16. ANOVA results for work hours following shift-restart break.

Source	df	SS	MS	*F*	*p*
Model	2	584.5107	292.2554	40.99	<0.0001
Error	1,773	12,354.8523	7.1292		
Corrected Total	1,735	12,939.3630			

Table 17. Post hoc Tukey's tests for work hours following shift-restart break.

Shift-Restart Method Comparison	Difference Between Means	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Significant
SBP vs. 10+ hour	1.7295	1.2499	2.2092	*
SBP vs. 34+ hour	2.0668	1.4808	2.6528	*
10+ hour vs. 34+ hour	0.3373	-0.0813	0.7558	

RISK AND SHIFT-RESTART METHOD

A mixed-effect NB model with a logarithmic link function was used to model SCE rate at the shift level as a function of an indicator variable for the SBP shift-restart method. Table 18 lists the results of the NB model, which show no significant difference between the rates of SCE occurrence in shifts following SBP shift-restart breaks and in shifts following 10+ hour or 34+ hour shift-restart breaks.

Table 18. SCE rate as a function of SBP shift-restart method.

Effect	Estimate	SE	df	*t*	*p*
Intercept	-0.5514	0.1956	96	-2.82	0.0058
SBP Indicator	-0.0976	0.1547	1,737	-0.63	0.5284

For each shift-restart method, the number of baselines and SCEs were counted in the shift immediately following the shift-restart method. Table 19 shows the distribution of baselines and SCEs in the shifts following each of the shift-restart methods. Shifts following 10+ hour breaks had 4,430 total events identified, and SCEs accounted for 1,599, or 36.09%, of the total events. Shifts following 34+ hour breaks had 784 events identified, and SCEs accounted for 280, or 35.71%, of the total events. Shifts following SBP breaks had 760 events identified, with the lowest SCE portion of events: 29.21% (or 222 SCEs).

Table 19. Distribution of SCEs and baselines for shifts following shift-restart methods.

Shift-Restart Method	SCE Count	SCE Percentage of Events	Baseline Count	Baseline Percentage of Events	Total Event Count
10+ hour	1,599	36.09%	2,831	63.91%	4,430
34+ hour	280	35.71%	504	64.29%	784
SBP	222	29.21%	538	70.79%	760

ORs were used to calculate the risk associated with the three shift-restart methods, comparing, for two shift-restart methods at a time, the total SCEs and baselines in the shifts following each shift-restart method. The 10+ hour and 34+ hour restarts were not found to have significantly different SCE risks (OR = 1.02, 95% CI = [0.87, 1.19]). However, both the 10+ hour and 34+ hour breaks were associated with a significantly higher risk than the SBP. The OR and 95% CI for the 10+ hour break compared to the SBP break were 1.37 and [1.16, 1.62], respectively. The OR and 95% CI for the 34+ hour break compared to the SBP break were 1.35 and [1.09, 1.67], respectively. Table 20 lists the ORs and CIs. Significant comparisons have confidence intervals that did not include 1 and are indicated with an asterisk (*).

Table 20. ORs and 95% confidence intervals for shift-restart methods.

Shift-Restart Method Comparison	OR	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Significant
10+ hour vs. SBP	1.37	1.16	1.62	*
34+ hour vs. SBP	1.35	1.09	1.67	*
10+ hour vs. 34+ hour	1.02	0.87	1.19	

CHAPTER 4. CONCLUSIONS

USAGE FACTORS

This investigation of the SBP provided insight into the SBP user population. The SBP appears to be used more frequently among drivers with less CMV driving experience. This finding could be the result of different assigned work schedules—perhaps drivers with more driving experience prefer or are assigned shifts that allow them to take the shift-restart break at home. Drivers who reported having arthritis or dizziness, vertigo, or another balance disorder used the SBP less often than those who reported not having these conditions. Arthritis has been found to be associated with poor sleep quality, non-restorative sleep, and fragmented sleep.(12,13) If drivers with arthritis are experiencing sleep issues, the longer 10+ hour or 34+ hour shift-restart methods may provide more time for sleep. Very little scientific research exists on the relationship between dizziness, vertigo, or other balance disorders and sleep. Only 5 of the 90 drivers reported experiencing these conditions. The current medical requirements set by the Federal Motor Carrier Safety Administration (FMCSA) do not automatically disqualify drivers with balance disorders or arthritis. However, medical practitioners are encouraged to fully understand how each driver's condition and symptoms affects his or her ability to control a CMV before qualifying the driver to drive CMVs.(14) Future research should consider how these conditions affect driver behavior and safety because little information currently exists on this topic.

Drivers who reported taking medications regularly used the SBP less often than did drivers who were not taking medications regularly. Research into the kinds of medications taken (which was recorded by drivers in their activity register), reasons for taking them, and their side effects may provide stronger insight into this relationship. Certain medications can have negative side effects such as drowsiness. In other instances, medications may alleviate medical conditions that otherwise could affect the driver (for example, anti-inflammatory drugs may relieve the driver of headaches or arthritic pain).

Drivers with long average delivery miles may be on the road for longer periods at a time than drivers with short or medium average delivery miles. Drivers on the road can still use the 10+ hour restart method in the sleeper berth, but the SBP may provide a more appealing option for the use of their rest and work time. The flexibility of the SBP could also explain why drivers using this method had longer drive and work hours; in other words, drivers may be driving and working longer hours when they can use the SBP to stop at a convenient time. Drivers with shorter drive and work hours may have shorter routes, allowing them to spend their rest time at home using the 10+ hour or 34+ hour shift-restart methods.

Although the factors above indicate that some differences may exist between the user populations of the different break types, a majority of driver characteristic factors had no association with break type use frequency. This finding is extremely interesting, in that it indicates that drivers using the SBP are not identical. Providing several safe options may appeal to drivers and allow them to determine how to get adequate rest while meeting HOS and work requirements.

SAFETY AND SLEEPER-BERTH PROVISION USE

An analysis of the SCEs and baselines in shifts following the 10+ hour restart, 34+ hour restart, and SBP breaks found that the SBP was associated with no higher—or even a lower—risk than the other shift-restart methods. When controlling for individual driver differences and only considering the rate of SCEs, the SBP was not found to have a significantly different risk compared to the other shift-restart methods (considered together). When analyzing the three shift-restart methods using ORs, which used SCE and baseline counts and did not control for individual drivers, the SBP was found to have a lower risk than either the 10+ hour or 34+ hour shift-restart method.

These findings are very important because they reveal that the SBP is not associated with a higher risk than the longer 10+ hour or 34+ hour shift-restart breaks. Each of the shift-restart methods has advantages and drawbacks. Offering drivers multiple break options may allow them to choose which break works best for their health or work day. The SBP provides drivers with flexibility in choosing when to pull over for breaks. Drivers may feel less inclined to drive in risky situations, such as in bad weather or traffic, when they can take a short break (e.g., 2 hours). Drivers may also use the more frequent, shorter breaks enabled by the SBP to perform secondary tasks, such as eating or reading, that otherwise might be performed while driving.

OVERALL CONCLUSIONS

The HOS regulations are in place to reduce driver fatigue and thereby increase driver safety. The 2005 HOS regulations, which were in place during data collection for the current study, included several ways for drivers to take rest breaks. The rest breaks give drivers an opportunity to rest and do non-work-related activities in between duty periods. This study compared the three rest break options available to drivers for differences in usage by various driver characteristics and in SCE risk. While a few driver characteristics (driving experience, arthritis, dizziness, vertigo, or another balance disorder, taking medications regularly) and work characteristics (average driving hours and working hours, delivery miles) showed significant differences in break type usage, many factors tested did not show differences. The SBP does not appear to be favored by one particular group of drivers. Using the SBP was found to be associated with no higher risk than the other break options. From these findings, the SBP appears to be a valuable break option for drivers, giving them flexibility to be safe and remain in compliance with HOS regulations.

The current study had several limitations. The participants were volunteers from companies that agreed to participate in the study; thus, they are not necessarily representative of the entire CMV driver population. Although the naturalistic data and activity register information provided incredible insight into driver tasks, non-driving tasks cannot be validated for correctness. It is possible that drivers may have intentionally or unintentionally left out tasks from their activity register or misrecorded the durations of tasks. In addition, drivers did not record the intention of the tasks or shift-restart breaks. The data analysis of this study used an algorithm to determine the shift-restart method preceding each shift. The algorithm was forced to make assumptions regarding the driver's shift based solely on the naturalistic data and activity register data. In addition, risk analyses did not consider participant-specific effects.

Future naturalistic driving research regarding the SBP should include focus groups to learn more about the reasons drivers choose to use the SBP over the other shift-restart methods. To determine if our study findings regarding the use and safety of the SBP are generalizable to a larger group of drivers, focus group studies should also include descriptive statistics on the demographics of drivers using the SBP. Future data will be collected under new HOS regulations, which still include the SBP as a shift-restart method. However, "on-duty" definitions, 34+ hour method usage allowances, and requirements for rest breaks during duty periods have changed. Future efforts should investigate how the usage preferences for shift-restart methods change under the new regulations. Shift-restart breaks could be further investigated regarding how they differ in the types and durations of activities taking place during the break, where the break takes place (home, sleeper berth, other rest option), and sleep quantity and habits. The SBP could also be studied for any cumulative effect on sleep or driving performance when the provision is used several times in a row.

APPENDIX. DRIVER DEMOGRAPHIC FACTORS AND ANALYSIS

The following demographic, health, and sleep-related factors were investigated to determine their relationships with SBP use: body build, age, and CMV driving experience; the presence of the health conditions stroke, head injury, motion sickness, inner ear problems, diabetes, migraine or tension headaches, depression, anxiety, arthritis, high blood pressure, brain tumor, epileptic seizures, auto-immune disorders, chronic fatigue syndrome, respiratory disorders, heart arrhythmias, other psychiatric disorders, chronic stress, dizziness or vertigo or other balance disorders, and whether the driver was currently taking medications; and narcolepsy, periodic limb movement, sleep apnea, restless leg syndrome, insomnia, caffeinated beverage consumption, daytime nap frequency, and sleep schedule regularity.

DEMOGRAPHIC FACTORS

Body build was self-reported by drivers and had three answer options: small, medium, or large frame. As shown in Table 21, the average proportion of shifts preceded by an SBP break was 0.15 for both small-frame and medium-frame drivers (*SE* = 0.02 and 0.01, respectively) and 0.14 for large-frame drivers (*SE* = 0.02). The proportion of shifts preceded by an SBP break for all drivers was tested for differences across body build using ANOVA. Table 22 shows the results. No significant difference was found in average proportion of shifts preceded by an SBP break across the three body builds.

Table 21. Body build counts and average proportion of shifts preceded by an SBP break.

Body Build	*N*	Average Proportion of Shifts Preceded by an SBP Break	SE Proportion of Shifts Preceded by an SBP Break
Small Frame	9	0.15	0.02
Medium Frame	55	0.15	0.01
Large Frame	33	0.14	0.02

Table 22. ANOVA results for body build.

Source	df	SS	MS	*F*	*p*
Model	2	0.0543	0.0271	1.08	0.3439
Error	94	2.3637	0.0251		
Total	96	2.4180			

Age was self-reported by drivers and was a continuous variable measured in years. The relationship between age and proportion of shifts preceded by an SBP break was investigated using a linear regression model. The model was not significant ($F = 1.40$, $p = 0.2405$). The model results are given in Table 23.

Table 23. Linear regression results for age.

Variable	df	Parameter Estimate	SE	*t*	*p*
Intercept	1	0.1813	0.0615	2.95	0.0040
Age	1	-0.0016	0.0013	-1.18	0.2405

HEALTH CONDITION FACTORS

Health conditions were self-reported by drivers. Several health conditions, listed in Table 24, had very low counts.

Table 24. Health conditions with low counts in the data set.

Health Condition	Count for Condition Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Present	Count for Condition Not Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Not Present
Stroke	1	0.0000	94	0.1147
Motion Sickness	3	0.0000	92	0.1172
Brain Tumor	0	.	95	0.1135
Epileptic Seizures	0	.	95	0.1135
Auto-Immune Disorders	0	.	95	0.1135
Chronic Fatigue Syndrome	0	.	95	0.1135
Other Psychiatric Disorders	1	0.0000	94	0.1147
Heart Arrhythmias	4	0.1717	91	0.1109
Chronic Stress	1	0.0000	94	0.1147

The health conditions listed in Table 25 were analyzed individually using the Kruskal-Wallis non-parametric test and found not to be significantly related with the proportion of shifts preceded by an SBP break.

Table 25. Health conditions analyzed with the Kruskal-Wallis non-parametric test.

Health Condition	Count for Condition Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Present	Count for Condition Not Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Not Present	Kruskal-Wallis χ^2	*p*-value
Anxiety	6	0.1920	89	0.1082	0.1116	0.7384
Depression	8	0.1366	87	0.1113	0.1415	0.7068
Diabetes	9	0.0373	86	0.1214	0.5280	0.4675
Head Injury	6	0.0984	89	0.1145	0.1397	0.7086
High Blood Pressure	20	0.0557	75	0.1289	2.2059	0.1375
Inner Ear Problems	7	0.1926	88	0.1072	0.4845	0.4864
Migraine or Tension Headaches	15	0.1111	80	0.1139	0.7205	0.3960
Respiratory Disorders	7	0.1416	88	0.1112	0.1160	0.7334
Wears Contacts	6	0.0664	91	0.1141	0.7384	0.3902

SLEEP HYGIENE FACTORS

Sleep hygiene and habits were self-reported by drivers. Several sleep hygiene factors, listed in Table 26, had very low counts.

Table 26. Sleep hygiene factors with low counts in the data set.

Sleep Hygiene Factors	Count for Condition Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Present	Count for Condition Not Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Not Present
Narcolepsy	0	0.0000	94	0.1141
Periodic Limb Movements	0	0.0000	94	0.1141
Sleep Apnea	3	0.0870	91	0.1150
Restless Leg Syndrome	2	0.0000	92	0.1166
Insomnia	2	0.0682	92	0.1151

The sleep hygiene factors listed in Table 27 were analyzed individually using the Kruskal-Wallis non-parametric test and found not to be significantly related to the proportion of shifts preceded by an SBP break.

Table 27. Sleep hygiene factors analyzed with the Kruskal-Wallis non-parametric test.

Sleep Hygiene Factors	Count for Condition Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Present	Count for Condition Not Present	Average Proportion of Shifts Preceded by an SBP Break in Drivers with Condition Not Present	Kruskal-Wallis χ^2	p
Do you drink caffeinated beverages?	86	0.1075	8	0.1855	0.5694	0.4505
Do you usually nap during the day?	21	0.0827	73	0.1232	1.0032	0.3165
Do you keep a fairly regular sleep schedule?	61	0.1013	32	0.1421	2.1134	0.1460

REFERENCES

1. Berman, J. (2006, March 1). Controversy continues over HOS sleeper-berth ruling. *Logistics Management, 45*(3), 16.

2. Darwent, D., Roach, G., & Dawson, D. (2012). How well do truck drivers sleep in cabin sleeper berths? *Applied Ergonomics, 43*, 442-446.

3. Belenky, G., Jackson, M. L., Tompkins, L., Satterfield, B., & Bender, A. (2012). *Investigation of the effects of split sleep schedules on commercial vehicle driver safety and health* (Report No. FMCSA-RRR-12-003). Washington, DC: Federal Motor Carrier Safety Administration.

4. Mackie, R. R., & Miller, J. C. (1978). *Effects of hours of service, regularity of schedules, and cargo loading on truck and bus driver fatigue* (Technical Report 1765-F NHTSA). Goleta, CA: Human Factors Research, Inc.

5. Hertz, R. P. (1988). Tractor-trailer driver fatality: The role of nonconsecutive rest in a sleeper berth. *Accident Analysis & Prevention, 20*(6), 431-439.

6. Blanco, M., Hickman, J. S., Olson, R. L., Bocanegra, J. L., Hanowski, R. J., Nakata, A., … Bowman, D. (2016). *Investigating critical incidents, driver restart period, sleep quantity, and crash countermeasures in commercial vehicle operations using naturalistic data collection* (Report No. FMCSA-RRR-13-017). Washington, DC: Federal Motor Carrier Safety Administration.

7. Blanco, M., Hanowski, R. J., Olson, R. L., Morgan, J. F., Soccolich, S. A., Wu, S., & Feng, G. (2011). *The impact of driving, non-driving work, and rest breaks on driving performance in commercial motor vehicles: Final report* (Report No. FMCSA-RRR-11-017). Washington, DC: Federal Motor Carrier Safety Administration.

8. Olson, R. L., Hanowski, R. J., Hickman, J. S., & Bocanegra, J. (2009). *Driver distraction in commercial vehicle operations* (Report No. FMCSA-RRR-09-042). Washington, DC: Federal Motor Carrier Safety Administration.

9. Hanowski, R. J., Blanco, M., Nakata, A., Hickman, J.S., Schaudt, W.A., Fumero, M.C., … Madison, P. (2008). *The drowsy driver warning system field operational test, data collection: Final report* (Report No. DOT HS 810 035). Washington, DC: National Highway Traffic Safety Administration.

10. Mosteller, F. (1968). Association and estimation in contingency tables. *Journal of the American Statistical Association, 63*(321), 1-28. Retrieved from http://www.jstor.org/stable/2283825

11. Woolf, B. (1955). On estimating the relationship between blood group and disease. *Annals of Human Genetics, 19*(4), 251-253.

12. Drewes, A. M., Svendsen, L., Taagholt, S., Bjerregård, K., Nielsen, K. D., & Hansen, B. (1998). Sleep in rheumatoid arthritis: A comparison with healthy subjects and studies of sleep/wake interactions. *Rheumatology, 37*(1), 71-81.

13. Taylor-Gjevre, R. M., Gjevre, J. A., Nair, B., Skomro, R., & Lim, H. J. (2011). Components of sleep quality and sleep fragmentation in rheumatoid arthritis and osteoarthritis. *Musculoskeletal Care, 9*(3), 152-159.

14. Federal Motor Carrier Safety Administration. (2014). *Federal Motor Carrier Safety Administration Medical Examiner Handbook.* Washington, DC: Author. Retrieved from http://nrcme.fmcsa.dot.gov/documents/FMCSAMedicalExaminerHandbook-2014MAR18.pdf