FMCSA's Naturalistic Truck Driving Research Program

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June 23, 2008

Research Division

Office of Analysis, Research and Technology

The Naturalistic Truck Driving Study: Overview of Methods and Key Results

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FMCSA Research Webinar
June 23, 2008

Acknowledgements

- Study was funded by the Federal Motor Carrier Safety Administration, Contract DTFH61-01-C-00049, Task Order #23
  - Task Order Manager: Bob Carroll
- *Technical Report (in Press)*
  - *Investigating Critical Incidents, Driver Restart Period, Sleep Quantity, and Crash Countermeasures in Commercial Vehicle Operations Using Naturalistic Data Collection*
    - Authors: Blanco, Hickman, Olson, Bocanegra, Hanowski, Nakata, Greening, Madison, Holbrook, and Bowman
    - Presentation support from Shelby McDonald at VTTI

Presentation Overview

- What is naturalistic data collection?
- Study approach
- Identifying safety critical events
- Data collected
- Key Findings
  - Restart period
  - Sleep
  - Countermeasures
- Conclusions

Naturalistic Data Collection

- Collecting driver behavior and performance data in a naturalistic environment
- Examples:
  - Light vehicle drivers commute to/from work (e.g., 100-Car Study)
  - Truck drivers operate their vehicles on revenue-producing runs (e.g., Sleeper Berth Study, Local/Short Haul Study)
- High validity
- Low control

Naturalistic Method

- Study participants use an instrumented vehicle for an extended period (e.g., several months to one year)
- Able to get detailed pre-crash/crash information along with routine driving behaviors
- Highly capable data acquisition systems (well beyond EDRs)
- Able to collect crash pre-cursor data and driver performance/behavior data using sensors and video cameras

Naturalistic Truck Driving Study

- Funded by FMCSA
- Data collection
  - Start: November 2005
  - End: May 2007
- Safety Partners:
  - Schneider National
  - Pitt Ohio Express
  - Best Dedicated
  - Beam Bros. Trucking

Study Objectives

- Collect naturalistic data to investigate issues related to crash risk
  - Restart period and safety-critical events
  - Sleep patterns and safety-critical events
  - Light vehicle – heavy vehicle interactions
  - Functional countermeasures
- Opportunity to investigate many other driver performance and safety issues with this type of data

Data Collection Approach

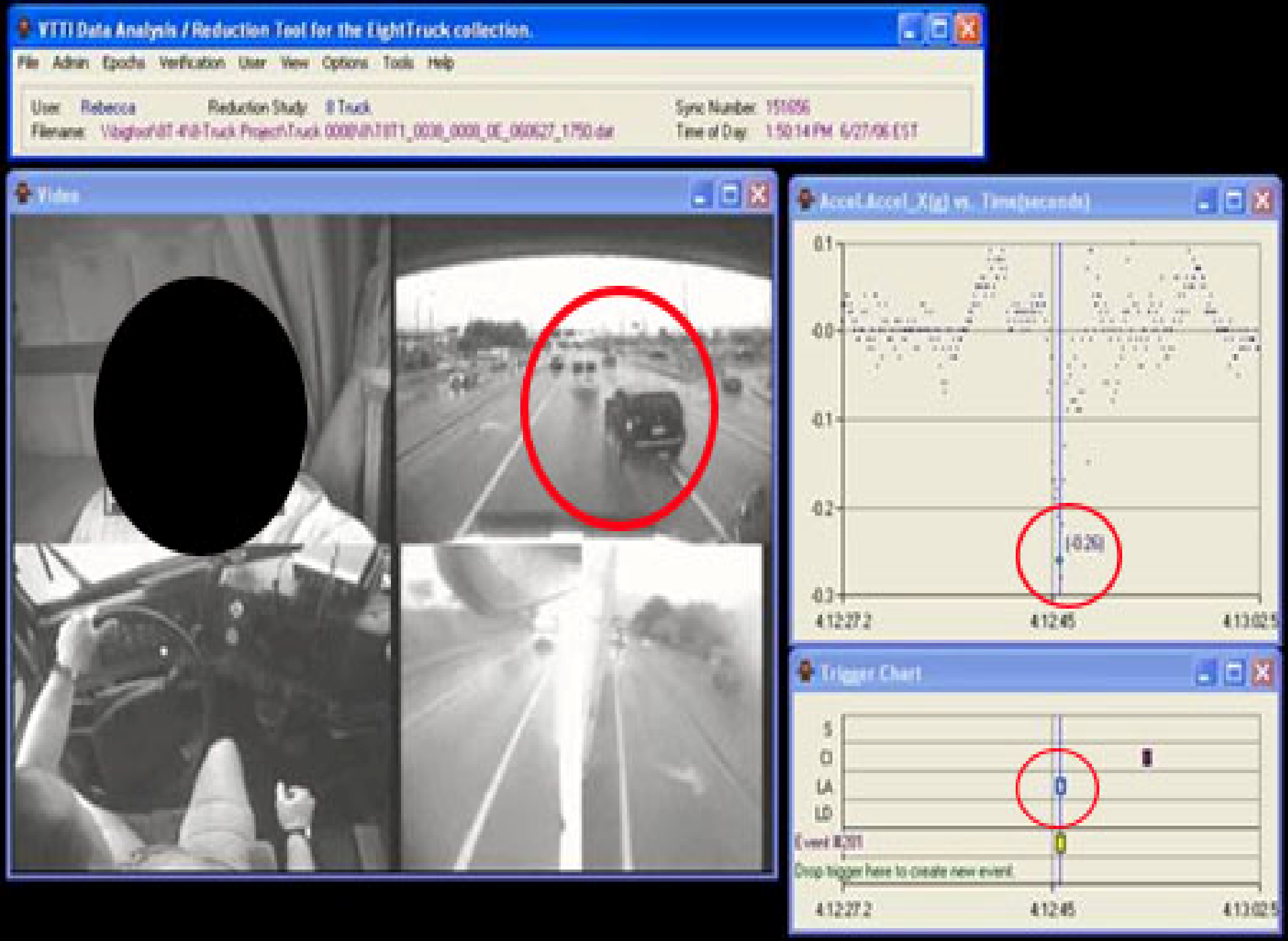
- 4 Fleet Companies – 7 Locations
- 100 Class-A CDL drivers
- 9 Instrumented Trucks
  - Continuous data collection
  - 4 wks of data per driver
- Driving performance
  - Kinematic and 5 video channels
- Sleep/Wake (Actigraph)
- Psychomotor Vigilance Test (PVT)
- Activities during on-/off-duty

Data Collection Statistics

- ~ 735,000 miles of driving data
- ~ 65,000 hours of actigraphy data
- ~ 6 terabytes of data
- Coupled with the dataset from DDWS FOT
  - Data from over 200 drivers
  - ~ 3M miles of driving data
  - ~ 250,000 hours of actigraphy data
- Provides opportunity to look at various CMV issues

Finding Safety Critical Event

- How are SCE identified?
- Sample event triggers
  - Longitudinal Acceleration
  - Time-to-Collision
  - Swerve
  - Lane Deviations
  - Critical Incident Button
  - Analyst Identified
- Validated with video review


VTTI Data Analysis / Reduction Tool for the Eight Truck collection
File Admin Epochs Verification User View Options Tools Help
User Rebecca
Reduction Study 8 Truck
Sync Number 151056
Filename
Time of Day 1:50:14 PM 6/27/06 EST
Video
Accel Accel_X(g) vs. Time(seconds)
0.1
0.0
-0.1
-0.2
-0.3
(-0.26)
4:12:27.2
4:12:45
4:13:02.5
Trigger Chart
S
O
LA
LD
Event #201
Drop trigger here to create new event
4:12:27.2
4:12:45
4:13:02.5

Data Coding

- Data Directory
  - Used classification categories found in GES, FARS, LTCCS, other databases
  - Listed all relevant variables, for example:
    - Weather
    - Road type
    - Traffic density
    - Event contributing factors
    - Other factors of interest

Safety Critical Event

- 3 Types
  - Crashes
  - Near-crashes
  - Crash-relevant Conflicts
- Crash
  - Contact with an object, either moving or fixed, at any speed

- Near-Crash
  - Any circumstance that requires a rapid, evasive maneuver (e.g., hard braking, steering) by the subject vehicle or any other vehicle, pedestrian, cyclist, or animal, in order to avoid a crash
- Crash-Relevant Conflict
  - …less severe evasive maneuver as compared to Near-Crash

Safety Critical Event Statistics

- 2899 safety-critical events
  - 13 Crashes (8 Tire Strikes)
  - 61 Near-Crashes
  - 1594 Crash Relevant Conflicts
  - 1215 Unintentional Lane Deviations
  - 16 Illegal Maneuvers

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- **Key Findings**
  - **Restart period**
  - **Sleep**
  - **Countermeasures**
- Conclusions

RQ1: Restart Period and Safety-Critical Events

1.1 How much time do drivers take off during their off-duty restart period before a safety-critical event?

1.2 Is there a relationship between restart period and safety-critical events?

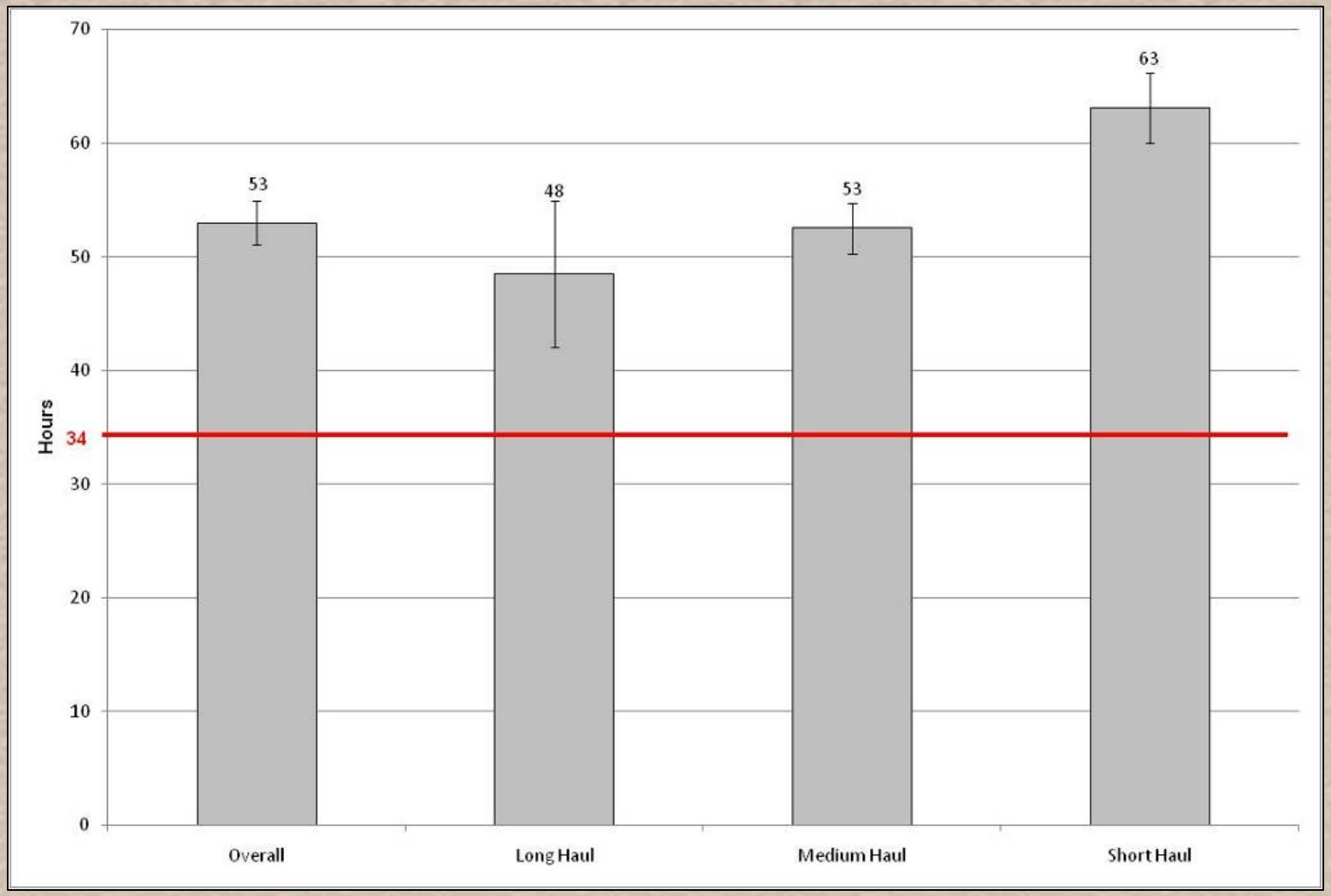
1.3 Is time from restart related to the type of safety-critical events?

Driver Classification

- Five US Census Bureau Categories
  - Local: less than 50 miles
  - Short: 50 to 100 miles
  - Short Medium: 100 to 200 miles
  - Long Medium: 200 to 500 miles
  - Long: Over 500 miles
- The three categories used:
  - Short: less than 100 miles
  - Medium: 100 to 500 miles
  - Long: Over 500 miles

1.1 Results: Restart Period Duration

Number of hrs during restart periods preceding SCE



Key Findings – Restart Period

RQ 1.1 How much time do drivers take off during their off-duty restart period before a safety-critical event?

- The average duration of the restart period before a safety-critical event was 53h every 5 days
  - In comparison, the duration of the restart before baseline events averaged 58h
  - Long-haul drivers restart (48h) < short-haul drivers (63h)
  - Medium-haul drivers restart averaged 53h
  - All 3 types of operations took on average more than the 34hr minimum off-duty restart required by FMCSA

Key Findings – Restart Period

RQ 1.2 Is there a relationship between restart period and safety-critical events?

- No relationship was found between the duration of the restart period and the safety-critical events

RQ 1.3 Is time from restart related to the type of safety-critical events?

- Results suggest that the number of safety-critical events is highest during the first day after restart
  - Consistent with Dingus et al. (2002)

RQ 2: Sleep Patterns and Safety-Critical Events

2.1 How many hours of sleep did the driver have 24 h before the safety-critical event?

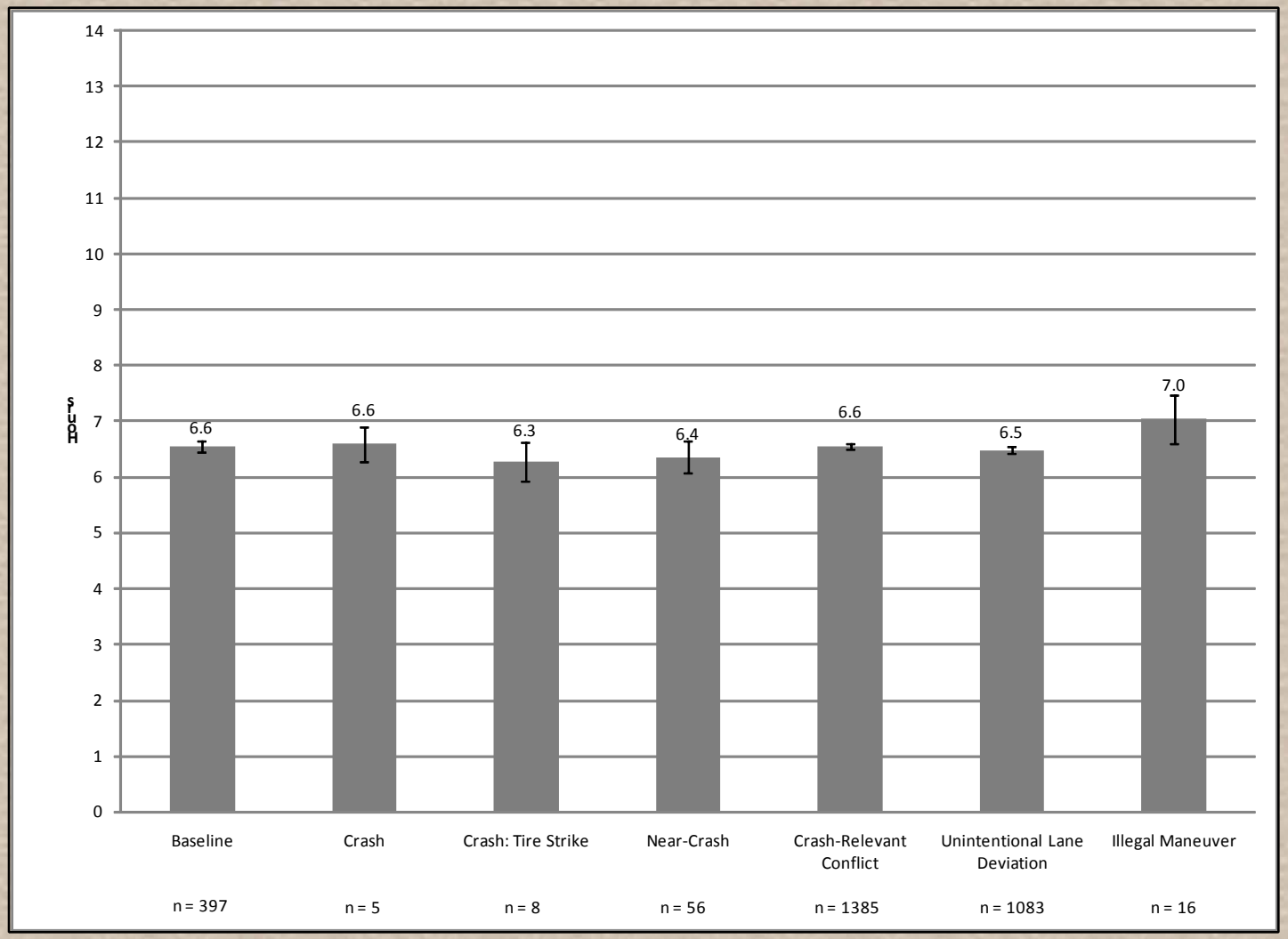
2.2 How many hours of sleep did the driver have since restart, before the safety-critical event happened?

2.3 What are the characteristics of the rest period preceding the safety-critical events (e.g., single sleep period, multiple sleep periods)?

2.4 Was the rest period before the safety-critical event taken on-duty or off-duty?

2.1 Results: Average Sleep Duration

Sleep 24 h before a SCE (at-fault & not at-fault)



Key Findings – Sleep

RQ 2.1 How many hours of sleep did the driver have 24 hours before the safety-critical event?

- Baseline
  - 6.6 h (CL: 6.4 - 6.8 h) during the 24 h before the baseline
- Safety-Critical Event
  - 6.5 h (CL: 6.4 - 6.6 h) during the 24 h before SCE
  - Hanowski et al. (2007)
    - 5.3 h before an at-fault SCE
    - 1.2 h difference may be attributed to a difference in the focus of analyses (at-fault SCE vs. all SCE)

Key Findings – Sleep

RQ 2.2 How many hours of sleep did the driver have since restart, before the safety-critical event happened?

- Baseline
  - 1.1 h more during their restart (7.2 h) than regular workday (6.1 h)
- Safety-Critical Event
  - Sleep since restart (5.9 h) and 24 h before a SCE (6.5 h) was less than that received during the restart period (7.0 h) preceding SCE

RQ 2.4 Was the rest period before the safety-critical event taken on-duty or off-duty?

- Most sleep periods were taken off-duty for both baseline and SCE

Key Findings – Sleep

RQ 2.3 What are the characteristics of the rest period preceding the safety-critical events (e.g., single sleep period, multiple sleep periods)?

- Most of the sleep received 24 h before a SCE or baseline involved a single sleep period
  - Some up to 4 sleep periods
  - 3^+ sleep periods were not predominant
- Average sleep period 24 h before (SP1)
  - 5.1 h of sleep, 7.0 h before Baseline
  - 5.0 h of sleep, 7.8 h before SCE
- Multiple sleep periods
  - Baseline: 5.2 h apart
  - SCE: 5.1 h apart

Functional Countermeasures

What are the functional countermeasures that may have ameliorated SCE?

- What is a functional countermeasure?
  - Main objective of the countermeasure, not restricted by existent technology
  - Prevent the genesis of the unsafe situation
  - Improve driver's response to the situation
- How were the countermeasures obtained?
  - Review of SCE
  - Interviewing drivers participating in NTDS

Key Findings – Countermeasures: Commercial Motor Vehicles

- Most frequent CMV countermeasures were:
  - Prevent ‘drift’ lane departures (79%)
  - Increase driver attention to forward visual scene (73%)
  - Improve general driver situation awareness and/or proactive/defensive driving (56.1%)
  - Increased driver alertness (14.4%)
- For the 5 crashes:
  - Improve general driver situation awareness and/or proactive/defensive driving (60%)
  - Increase/improve driver use of mirrors or provide better information from mirrors (40%)

Key Findings – Countermeasures: Other Vehicles

- Most frequent countermeasures for other vehicles were:
  - Improve general driver situation awareness and/or proactive/defensive driving (4.9%)
  - Improve driver night vision in the forward field (4.3%)
  - Increase driver recognition/appreciation of specific highway crash threats: vehicle in right adjacent lane (1.1%)
  - Increase driver recognition/appreciate of specific highway crash threats: vehicle in left adjacent lane (1%)

Future Research – Use Two Datasets (NTDS, DDWS FOT)

- Relationship between work/rest parameters, drowsiness, and safety-critical events:
  - On-duty vs. Off-duty sleep and SCE
  - Sleep during the 60/70 h on-duty limit
  - Sleep pattern and SCE
  - At-fault, not at-fault, vs. overall comparisons (analysis similar to the ones presented today)

Future Research – Use Two Datasets (NTDS, DDWS FOT)

- Impact of non-driving activities and circadian cycle effects on involvement in safety-critical events:
  - SCE = f (non-driving “on-duty” work activities 24 h prior)
    - Common non-driving “on-duty” activities 24 h prior SCE
  - SCE = f (non-driving “off-duty” work activities 24 h prior)
    - Common non-driving “off-duty” activities 24 h prior SCE

Future Research – Use Two Datasets (NTDS, DDWS FOT)

- Characteristics of the LV-HV interaction safety-critical events:
  - Critical reason analysis using both datasets for at-fault SCE
  - Differences due to type of operation, type of vehicle, etc.
  - Error types(recognition, decision, or performance errors)
  - Infrastructure characteristics by type of SCE

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