MOTOR CARRIER SCHEDULING PRACTICES AND THEIR INFLUENCE ON DRIVER FATIGUE

Presented to: FMCSA Motor Carrier Safety Advisory Committee

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Overview of Study

- Objectives
  - define or develop typology of truck driving environments and percentage of drivers within different environments
  - assess operational scheduling requirements of truck carriers that affect driver fatigue
  - identify scheduling and safety practices that influence driver fatigue and safety performance

- Project design and organization
  - Part 1: Development of CMV Driver Fatigue Model -- identify scheduling requirements that may affect driver fatigue
  - Part 2: Truck Stop Study -- develop typology of truck driving environments

  (Crum et. al, 2001)
  - Part 3: Truck Company Study -- assess scheduling requirements and safety practices that influence truck driver fatigue

  (Crum and Morrow, 2002)

Research Team

- Iowa State University
- The Trucking Research Institute (ATA Foundation)
- The Private Fleet Management Institute (National Private Truck Council)

Part 1: Model Development

- Literature review (55 relevant studies)
- Focus groups (industry reps)
- 13 carrier site visits and interviews with safety directors, top management, dispatchers, and drivers

Commercial Motor Vehicle (CMV) Driver Fatigue Model

- CMV Driving Environments
  - Regularity of time (4)
  - Quality of rest (8)
  - Trip control (13)
- Economic Pressures
  - Scheduling demands of commerce (5)
  - Driver economic & personal factors (6)
  - Carrier economic factors (7)
- Carrier Support for Driving Safety (11)

Commercial Motor Vehicle (CMV) Driver Fatigue Model

CMV Driving Environments

Regularity of Time
- % of time driving same hrs.
- No. different 4-hr. time zones driving
- Variability of work
- Most hrs. driven per wk. last 2 yrs.

Quality of Rest
- % of time spent sleeping at home
- % of sleep at nighttime
- Difficulty finding a place to rest
- % driving time between 8PM-8AM
- No. hrs. uninterrupted sleep
- No. hrs. uninterrupted sleep between 6 AM-10 PM
- Recovery time
- Team driving

Trip Control
- Regularity of route
- Freedom to choose own routes
- Schedule control
- Frequency you can choose rest stops
- Extent that rest stops can be forecast accurately
- Assistance with route from dispatcher
- % time spent loading/unloading
- % time spent waiting
- % time spent doing "other"
- No. different consignees contacted daily
- No. companies contacted daily
- No. loads and trips daily
- Perceived pressure to be on-time

Economic Pressures

Scheduling Demands of Commerce
- Time allotted by shippers/receivers
- Shipper awareness of fatigue issues
- Shipper concern with fatigue issues
- % business from brokers
- % time spent waiting

Driver Economic or Personal Factors
- Sufficient income from driving
- Non-financial incentives to drive when tired
- Desire for more miles
- Rewards/penalties for on-time deliveries/arrivals
- Rewards for safe driving performance
- Personal pride in on-time performance

Carrier Economic Factors
- Penalties levied on carrier for late deliveries
- Pressure on dispatchers to accept/hurry loads and trips
- Rewards/penalties for dispatchers for on-time deliveries/arrivals
- Rewards/penalties for dispatchers for safe driving
- Pressure on dispatcher to minimize deadhead miles
- Dispatchers emphasize business over safety
- Co. emphasizes business over safety

Fatigue

- Self-reported frequency of driving "tired"
- Self-reported no. loads rejected by driver because of tiredness in last 2 yrs.
- Self-reported no. of close calls in last 2 yrs. because driver was less than alert
- Perceived frequency of driving tired by other co. drivers
- Average no. of rest breaks during 10 hr. driving run
- Length of average rest break

Crashes

Carrier Level
- Company crash rate

Driver Level
- Self-report no. of reportable crashes in last 2 yrs.
- Self-report no. of chargeable crashes in last 2 yrs.

Carrier Support for Driving Safety

- Operational practices to avoid fatigue
  - Naps allowed
  - Use of relay and/or driver teams
  - Selectivity in accepting freight
  - Safety equipment
  - Minimal night driving
  - Driver autonomy with respect to tiredness
  - Assistance w/ loading/unloading
- Access to mgmt. above dispatcher
- Recognition for safe driving
- Co. commitment to HOS regulations
- Top mgmt. concern with fatigue & safety
- Dispatcher concern with fatigue & safety
- Safety climate
- Driver training about fatigue
- Dispatcher training about fatigue
- Top mgmt. understanding of fatigue
- Perceived org. commitment to safety
  - Driver input into safety
  - Continuous training on driving safety
  - Overall co. commitment to safety
  - Cordial driver/dispatcher relationships

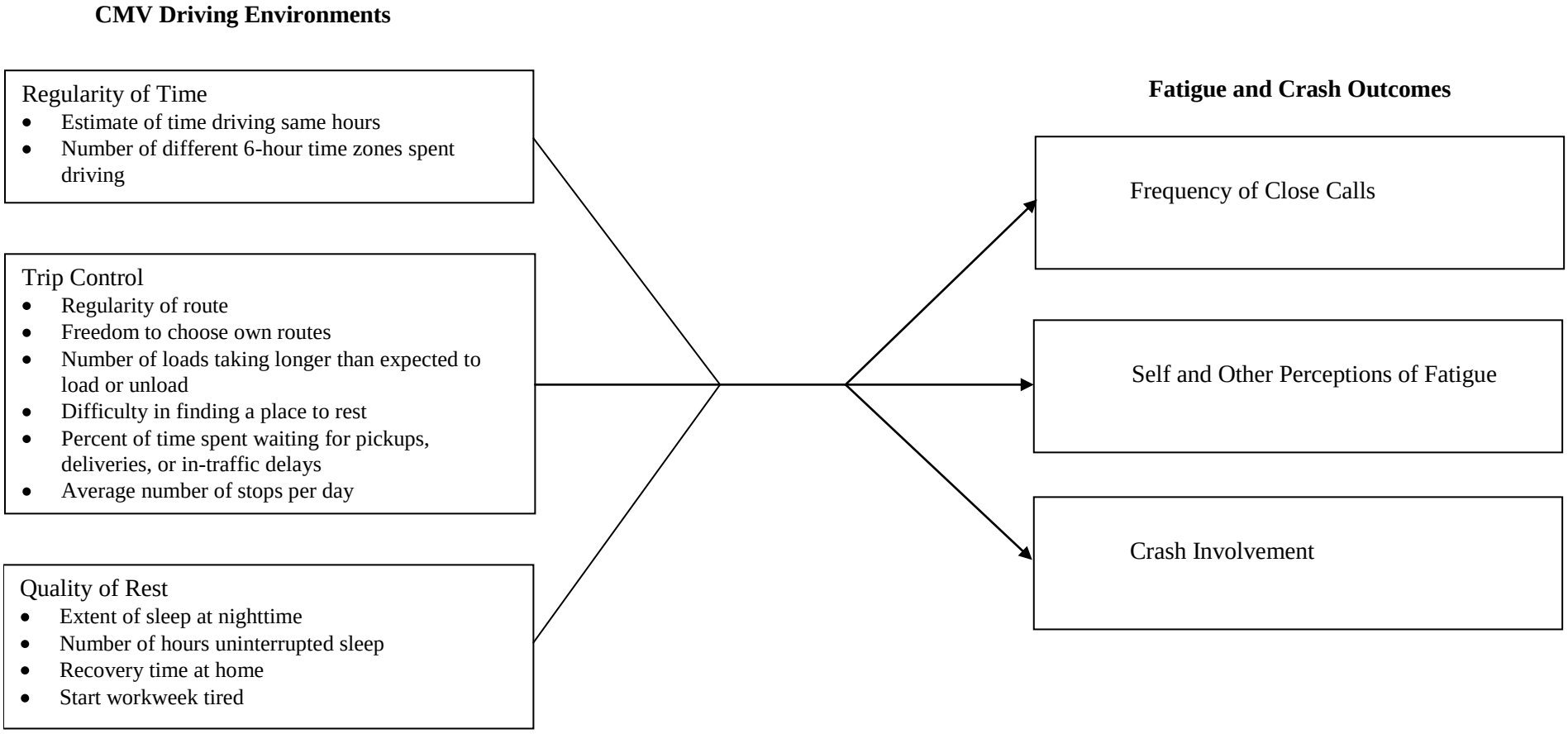
Part 2: Truck Stop Study

- Truck drivers (n=502) were sampled at five truck stops (California; Colorado; Georgia; Iowa; Maryland)
- Driver profile: predominantly interstate and for-hire; 60% company/34% owner operator
- Crash outcome measure characterized by restriction in range (i.e., 80% no reportable crashes; 93% no chargeable crashes over last two years)

Model Revision

- 12 indicators for CMV driving environments evolved from data reduction efforts.
- 3 indicators of fatigue and crash outcomes evolved from factor analysis:
  - Frequency of close calls (near accidents) due to lack of alertness
  - Perceptions of fatigue as a problem for self and other drivers
  - Two normalized crash involvement indicators (reportable, chargeable)

CMV Driving Environments And Fatigue And Crash Outcomes Of Over-The-Road Truck Drivers



Results of Regression Analysis Testing Driving Environment Indicators of Fatigue

Driving Environment Indicators	Close Calls	Self and Others' Perceptions of Fatigue	Crash Involvement
Regularity of Time			
Driving the same hours		-.10*	
Number of time zones	-.11*		
Trip Control			
Regularity of route		-.09*	
Can choose own routes			
Longer than expected load time	.12*	.18***	
Difficulty in rest place			
Schedule delays			
Average stops per day			.10[a]
Quality of Rest			
Extent of sleep at night			
Uninterrupted hours of sleep		-.09*	
Frequency at home			
Start workweek tired	.18***	.29***	.09 [a]
F	2.95***	11.41***	1.67 [a]
Adjusted R^2	.05	.23	.02

*$p \leq .05$ **$p \leq .01$ ***$p \leq .001$ [a] $p \leq .10$

Typology of Driving Environments

- We used the three driving environment characteristics to form a 2 x 2 x 2 typology of truck driver work environment.
- This results in 48 possible combinations (i.e., 2 x 6 x 4 indicators).
- ANOVA tests revealed that this typology does a very good job of predicting fatigue.
- For illustration purposes, we present the typology using the single best predictor from each characteristic.

Best Indicator Predictors of Fatigue

- Regularity of Time (2)
  - Frequency that driver drives the same hours each day
- Trip Control (6)
  - Percent of loads taking longer than expected to load or unload
- Quality of Rest (4)
  - Frequency with which drivers start their workweek tired (i.e., insufficient recovery)

Distribution of Drivers by Driving Environment (Driving the Same Hours, Longer Than Expected Load Times, Starting Workweek Tired)

	Driving Environment	Frequency	Percent
1.	Drive regular time, low load wait time, do not start workweek tired	72	14.5
2.	Drive regular time, low load wait time, start workweek tired	79	15.9
3.	Drive regular time, high load wait time, do not start workweek tired	53	10.7
4.	Drive regular time, high load wait time, start workweek tired	100	20.1
5.	Drive irregular time, low load wait time, do not start workweek tired	39	7.8
6.	Drive irregular time, low load wait time, start workweek tired	46	9.3
7.	Drive irregular time, high load wait time, do not start workweek tired	26	5.2
8.	Drive irregular time, high load wait time, start workweek tired	82	16.5
	Total	497	100%

- First cell is clearly the preferred from a fatigue minimization perspective (drive at regular times on day-to-day basis, wait time for loading and unloading is as expected, and low frequency of starting workweek tired).

- The eighth cell is clearly the worst (drive irregular times on day-to-day basis, waiting time for loading and unloading is longer than expected, and usually start workweek tired).

Driving Environment (Driving the Same Hours, Longer Than Expected Load Times, Starting Workweek Tired) as Predictors of Close Calls, Self and Others' Perception of Fatigue, and Crash Involvement

Fatigue and Crash Outcome	Range	Driving Environment Means 1	2	3	4	5	6	7	8	F
Close Calls	6-28	10.06	11.09	11.78	12.18	9.97	12.89	11.27	12.67	4.62*
Self & Others' Perceptions of Fatigue	6-26	11.55	14.65	13.33	16.32	12.15	15.76	14.96	17.43	18.17*
Crash Involvement	0-5.49	.00	.11	.00	.21	.00	.16	.00	.14	1.55

*$p \leq .001$

Findings and Implications

- Carriers should provide adequate recovery time, and educate/encourage drivers to use this time wisely.
- Carriers and shippers need to work together to improve scheduling and performance of loading and unloading activities.
- Carriers should create regular schedules to the extent possible.
- Drivers need to obtain at least five hours of uninterrupted sleep in a 24-hour period.

Part 3: Truck Company Study

- Objective: to assess scheduling requirements and safety practices that influence truck driver fatigue
- Sample firms: 116 trucking companies; randomly sampled from three safety performance-stratified groups
- Sample respondents include top mgmt., safety directors, dispatchers, and drivers in order to obtain necessary data for non-environment components of CMV Driver Fatigue Model

- Drivers (n = 279) in Part 3 are different from truck stop study respondents
  - About one-half from private fleets
  - 86% company/12% owner operators/2% other
  - Twice as many stops per day (5 vs. 2.4)
  - Crash performance about the same

Revised Commercial Motor Vehicle (CMV) Driver Fatigue Model

CMV Driving Environments

Regularity of Time
- Estimate of time driving same hours
- Number of different 6-hour time zones spent driving

Quality of Rest
- Start work tired

Trip Control
- Difficulty in finding a place to rest
- Average number of stops per day

Economic Pressures

Scheduling Demands of Commerce
- Percent of shippers and receivers providing adequate time (dispatchers' perceptions)
- Size of delivery/arrival window
- Percent of business from brokers
- Percent of time loading or unloading

Driver Economic or Personal Factors
- Personal motivations to continue driving when tired
- Drivers compensated for on-time deliveries/arrivals
- Drivers penalized for late deliveries/arrivals

Carrier Economic Factors
- Pressure on drivers to accept/hurry loads and trips (driver's perceptions)
- Pressure to bend rules (drivers' perceptions)
- Pressure to dispatch loads and trips (dispatchers' perceptions)
- Dispatcher evaluation based on operating efficiency

Fatigue and Crash Outcomes

- Frequency of close calls
- Self and other perceptions of fatigue
- Crash involvement

Carrier Support For Driving Safety

- Safe driving culture (drivers' perceptions)
- Voluntary attendance at safety and training meetings
- Assistance with loading/unloading
- Company policies which minimize nighttime driving

Hierarchical Regression Analysis of Operational Scheduling Requirements and Carrier Support for Driving Safety on Fatigue and Crash Involvement

Operational Scheduling Requirements and Carrier Support for Driving Safety	Close Calls		Self and Others' Perceptions of Fatigue	
	$Step_1$	$Step_2$	$Step_1$	$Step_2$
Step 1: Operational Scheduling Requirements				
Driving the same hours				
Number of time zones				
Start workweek tired	.20*	.23*	.22*	.18*
Difficulty in finding a place to rest	.21*	.23**		
Average number of stops per day				
Percent of shippers and receivers providing adequate time	-.14[a]			
Size of delivery window			-.23**	-.26**
Percent of business from brokers				
Percent of time spent loading or unloading				
Personal motivations to continue driving when tired				
Drivers compensated for on-time deliveries				
Drivers penalized for late deliveries				
Pressure on drivers to accept/hurry loads (drivers' perceptions)				
Pressure to bend rules (drivers' perceptions)			.17[a]	.
Pressure to dispatch loads (dispatchers' perceptions)				
Dispatcher evaluation based on operating efficiency			.15[a]	
Step 2: Carrier Support for Driving Safety				
Safe driving culture (drivers' perceptions)				
Voluntary attendance at safety and training meetings		-.15[a]		-.16*
Assistance with loading/unloading				-.20*
Company policies which minimize nighttime driving				-.18*
F	2.93***	2.66***	4.02***	4.39***
Change in F		1.43		4.13**
Change in R^2	.29	.03	.36	.08**
Adjusted R^2	.19	.20	.27	.34

*$p \leq .05$ **$p \leq .01$ *** $p \leq .001$ [a] $p \leq .10$

Findings and Implications

- CMV Driving Environments
  - Starting workweek tired (i.e., insufficient recovery) was again the single most significant factor
  - Difficulty in finding a place to rest emerged as a significant factor

- Economic Pressures
  - Shippers/receivers play key role via scheduling practices/requirements and actual physical interface
  - Company pressure on drivers and dispatchers has an influence on fatigue
  - Carriers' evaluation and reward/penalty methods have an influence on fatigue

- Carrier Support for Driving Safety
  - Company safety and training meetings affect driver fatigue
  - Carrier assistance with loading/unloading is associated with less fatigue
  - Carrier policies which minimize nighttime driving are associated with less fatigue
  - Carrier safety practices have an incremental impact on drivers' perceptions of fatigue beyond the effects of scheduling requirements and practices

Additional Analysis of Data
(Morrow and Crum, 2004)

- Randomly selected one driver from each of the 116 companies
- Focused on truck driving environment and company safety management practices
- Findings
  - Significant factors predicting either driving while fatigued or close calls due to fatigue: Insufficient recovery time, schedule irregularity, difficulty finding rest places, and average miles driven per week

- Company safety management practices added to the amount of explained variation in fatigue while driving and frequency of close calls
- Driver perceptions of a weak safety climate and pressure from dispatchers to continue driving when tired were associated with greater frequency of experiencing fatigue while driving
- Policies to minimize driver loading and unloading were associated with fewer close calls

Step and Predictor	Model 1: Fatigue While Driving		Model 2: **Frequency of Close Calls**	
	Step 1	Step 2	Step 1	Step 2
Step 1: Fatigue-inducing Factors				
Work overload-avg. miles/wk		.20†		
Schedule regularity			.23*	.20*
# 6-hour time blocks				
Difficulty finding rest places			.23*	.20*
Adequacy of sleep				
Insufficient recovery	.41***	.32***	.28**	.19*
% time loading				
Step 2: Company Safety Management Practices				
Safety climate		-.25**		
Minimize nighttime driving				.26**
Minimize loading/unloading		-.15†		-.22*
Pressure to drive		.22*		.20†
F	5.34***	6.93***	3.58**	5.14***
Change in F		7.06***		6.20***
Change in R^2	.31	.18	.24	.19
Adjusted R^2	.25	.42	.18	.35

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{\dagger}p < .10$.

CONCLUSIONS

- The CMV Driver Fatigue Model developed in this study does a reasonably good job of predicting driver fatigue in the trucking industry.
- All parties involved in freight transportation by truck have an impact on driver fatigue.
- The indicators in the model provide a good focal point for motor carrier safety efforts.

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