Tenth International Conference on Managing Fatigue: Abstract for Review

Predicting Performance and Safety Based on Driver Fatigue

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Problem

Fatigue impairs neurobehavioral performance in general, and vigilant attention and reaction time in particular, thereby diminishing a driver's ability to safely operate a motor vehicle. There is a need to quantify the relationship between driver fatigue and driver performance and safety, in terms of metrics already being collected by many transportation companies. Such measures will enable the efficient selection of fatigue countermeasures that are cost-effective and deliver expected operational benefits.

Method

We developed an analytic approach that estimates driver fatigue based on a biomathematical model and then estimates performance as a function of fatigue. The analysis used deidentified data from a field study of 106 US truck drivers, including 44 local drivers, 26 regional drivers, and 36 over-the-road (long-distance) drivers. Drivers were studied across two duty cycles intervened by a restart break of at least 34h. Data collected included drivers' official duty logs, sleep patterns measured around the clock with wrist actigraphy, and continuous measurement of vehicle performance. A subset of 48 drivers was included in the present analysis, with the remaining subset of 58 drivers being reserved for future analysis and validation.

A two-step algorithmic approach was developed that: (1) estimated driver fatigue based on sleep patterns using a biomathematical model published by McCauley and colleagues; and (2) estimated driver performance in terms of a metric related to safety: hard braking events. Driving periods were segmented into 30min bins and braking events were identified within each bin based on the presence of the brake signal captured from the vehicle. Hard braking incidents were defined as braking events with decelerations greater than 4mph/s and expressed in terms of frequency per 1,000 mi driven. Estimated fatigue was assessed for each 30min bin associated with a hard braking incident. Linear mixed-effects regression was used to estimate the relationship between fatigue and the rate of hard braking. The analysis controlled for time of day to account for systematic variations in traffic density.

Results

The frequency of hard braking incidents increased as predicted fatigue levels worsened, approaching statistical significance after accounting for time of day. For each increment on the fatigue scale, the frequency of hard braking incidents increased by 0.36 incidents per 1,000 miles (SE=0.21, p=0.08).

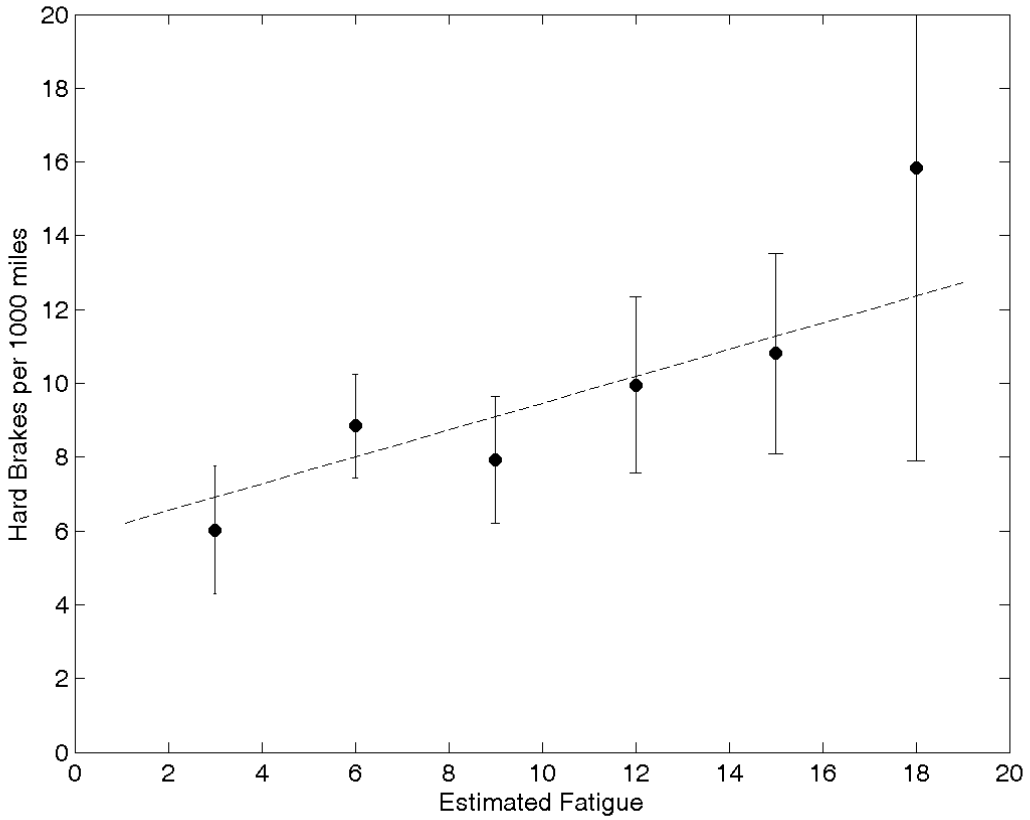

Figure 1. Incidence of hard braking as a function of estimated fatigue in 48 truck drivers. As predicted fatigue scores worsened, drivers tended to slam the brakes more frequently.

Discussion

These data provide proof of concept for a two-step approach that estimates fatigue based on drivers' sleep patterns and then predicts driving performance in terms of an operational metric related to safety (i.e., hard braking incidents). In a sample of truck drivers, we found that the frequency of hard braking increased with higher predicted fatigue scores. Together with previous findings that fatigue impacts drivers' psychomotor vigilance, duration of eye closure, and fuel use, this result highlights the importance of mitigating fatigue to improve safety and reduce costs in commercial motor vehicle (CMV) operations.

Validation with blinded data sets is underway to investigate the prediction accuracy of our analytic approach. Once validated, this will provide CMV operators with a tool to assist with quantitative evaluation of the cost and benefit of fatigue countermeasures, using outcome metrics they may already be collecting.

Summary
A two-step analytical approach was developed that involved estimating fatigue based on recent sleep history using a biomathematical model, and then predicting operationally relevant performance based on fatigue. A proof of concept analysis was conducted for hard braking incidents from deidentified data collected on 48 truck drivers in a recent field study. The data showed that the frequency of hard braking incidents increases with higher predicted fatigue. Once validated, this analytic approach will provide a tool to predict important operational outcomes (such as hard braking events). This will be valuable to demonstrate the need for, and document the benefits of the implementation of fatigue countermeasures.

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