RAILROAD WORK SCHEDULES AND FATIGUE

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Fatigue may be a major source of human error accidents in the rail industry. However, because there is no reported indicator of fatigue at the time of accidents, it has been difficult to determine the contribution of work schedules to fatigue and human factors accident risk. Biomathematical fatigue models permit the objective assessment of fatigue so that work and rest can be scheduled to minimize fatigue. Such a model could be used as a component of fatigue risk management and to determine the role of fatigue in accidents. To be useful, a fatigue model must be validated and calibrated. Validation means that the model predicts fatigue-related performance errors, and calibration means that the model's predictions can be related to specific levels of human error risk. A valid fatigue model should predict higher levels of fatigue (based on opportunities to sleep and an accident's time of day) when there exists a greater likelihood of human factors accidents. By comparison, fatigue levels should have a weaker or no relationship to the likelihood of nonhuman factors accidents. The U.S. Federal Railroad Administration (FRA) has recently completed a study to validate and calibrate a biomathematical fatigue model for use in the rail industry. The project examined 30-day work histories of locomotive crews prior to 400 human factors accidents and 1000 nonhuman factors accidents. A biomathematical fatigue model estimated crew effectiveness (the inverse of fatigue) based entirely on work schedule information and opportunities to obtain sleep. A reliable linear relationship existed between crew effectiveness and the risk of a human factors accident ($r = -0.93$); no such relationship was found for nonhuman factors accidents. This result satisfied the criteria for model validation. A reliable time of day variation occurred in human factors accidents ($r = 0.71$) but not in nonhuman factors accidents. The risk of human factors accidents was elevated at any effectiveness score below 90 and increased progressively with reduced effectiveness. At an effectiveness score ≤ 50, human factors accidents were 65 percent more likely than chance. Human factors accident risk reliably increases when effectiveness goes below 70, a value that is the rough equivalent of a 0.08 blood alcohol level or being awake for 21 hour following an 8-hour sleep period the previous night. Below an effectiveness score of 70, accident cause codes indicated the kinds of operator errors consistent with fatigue, confirming that the relationship between accident risk and effectiveness was meaningful.

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