The Potential for Effective Training of Logging Truck Drivers

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Review

HIGHLIGHTS

- Commercial truck drivers are a significant component of the logging workforce, and driver qualifications are an important component of managing risk.
- Some error types important in crash causation involve cognitive factors, which are effectively addressed by lecture or on-line training.
- There is evidence for the effectiveness of lecture-type driver training as an intervention for managing fatigue, situational awareness, and driving behavior.
- Adoption of trained behavior is supported by individual factors, a company safety culture, and supervisor feedback.

ABSTRACT. *The logging industry relies on owner-operators and employed commercial drivers, who comprise up to 40% of logging employment, to transport products from the forest to the mill gate. Truck drivers are exposed to many of the same risks as logging workers as well as additional risks from vehicle crashes. Vehicle crash risks contribute to risk of personal injury and liability related to public safety, which are critical reasons for enhancing driver qualifications. Driver qualifications can be influenced by hiring better drivers and improving drivers' skills through training even after they have received their commercial driver's license. To explore the effectiveness of driver training in the logging industry, we reviewed studies of commercial driver training assessment and training interventions that included lectures (on-line or in-person) as a main component. Decision errors and violations are important in crash causation and involve cognitive skills, which are addressed by this type of training. Additionally, lecture training is more accessible than behind-the-wheel or simulator training for logging operations that employ just a few drivers. In their efforts to improve driver qualifications, large commercial carriers often provide driver training, reinforce the training through monitoring, and rely heavily on driver selection. The literature supports the effectiveness of training related to cognitive factors, including fatigue management, behavior, and situational awareness. Successful lecture training interventions are accompanied by individual feedback or coaching. Training that produces measurable outcomes (behavior or crash risk) is supported by a suite of factors involving the trainee, the training, and the company or supervisor.*

Keywords. *Commercial vehicles, Logging, Training, Trucking.*

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Truck drivers account for more than 20% of all logging employees (BLS, 2020b), and many drivers that serve the logging industry are not employees of logging companies. Gallagher et al. (2006) and Mason et al. (2008) reported that about half of drivers were owner-operators. More recently, Conrad et al. (2018) indicated that 75% of logging companies in South Carolina and Georgia relied on non-employee contract drivers. Both employee and owner-operator drivers are exposed to the risk of vehicle accidents on the road, as well as many of the same risks as logging workers (Conway et al., 2017; de Hoop, 2017; Lagerstrom et al., 2017; Smidt et al., 2018). Between 2011 and 2018, 24% of logging industry fatalities were classified as transportation incidents involving vehicles. Truck drivers employed by logging companies accounted for 16% of logging industry fatalities (BLS, 2020a). Improving transportation safety is important to the industry and is a key component of addressing public safety concerns about logging trucks. In 2017, 148,000 persons were injured and 4,761 were killed in large truck crashes (FMCSA, 2019). More than 12 million registered trucks drive almost 300 billion miles per year, resulting fatal and injury crash rates of 1.42 and 34.4 per 100 million miles driven, respectively. Crash rates appear to be higher for logging trucks than for other large trucks (Metcalfe and Evanson, 2000; Greene et al., 2007; Cole et al., 2019). Public concern about logging truck safety involves the appearance of logging trucks (the condition of the truck and the nature of the load) and local publicity about crashes involving logging trucks (Conrad, 2017).

For some time, the market for truck drivers, including logging truck drivers, has been highly competitive (Baker and Mendell, 2016). Because forest products are a globally competitive commodity, cost control in timber harvest and transport is important (Siry et al., 2006). The cost control measures commonly used in logging transportation include the use of older trucks and trailers (Gallagher et al., 2006; Cole et al., 2019) and the employment of higher-risk drivers (less experience, driving violations, and previous crash involvement). The potential liability of both substandard trucks and higher-risk drivers has contributed to elevated insurance premiums, further reducing operating margins (Conrad, 2017).

Logging truck drivers must have a commercial driver's license (CDL), which requires passing a written exam and a driving test. Although not currently required, many drivers earn a CDL after attending a training program. However, many commercial carriers do not regard a CDL or entry-level training as indicators of driving competency (Knipling et al., 2003; Chen et al., 2015; Gargoum et al., 2017). Driving a logging truck introduces additional challenges of driving off-road and in poor conditions, unique loading and unloading procedures, and loads with a high center of gravity and overhang (Bjerklie, 2019). Stakeholders in logging have identified training as a method to increase the skills of logging truck drivers (Koirala et al., 2017; Conrad, 2018). Training objectives include increasing the supply of qualified drivers, changing driver behaviors related to crash risk, and reducing the rate of crash involvement. Even if training is effective and measurable, the impact on crash involvement might take years to observe. As a more immediate result, insurance providers could recognize driver behavior changes that are affected by training. Because errors and violations have been identified as major contributors to crash involvement (Treat et al., 1979; Najm et al., 1994), training that helps to reduce errors directly (e.g., improving situational awareness) and indirectly (e.g., fatigue management) may be an effective intervention. Human factors and the probable related errors and violations were found to be significant in crash involvement (Greene et al., 2007; Cole et al., 2019) and injury likelihood (Shipp et al., 2019) in logging transportation.

Logger training programs for company owners and supervisors have consistently

addressed transportation safety issues. Half of the logger training programs in the Sustainable Forestry Initiative (SFI) program reported transportation safety as a primary training topic or included in continuing education (FRA, 2018). SFI is a forest products certification program that presents claims regarding adoption of sustainable practices in forest management, logging, and forest products manufacturing (www.sfiprogram.org). Seminars and workshops addressing logging truck safety have been widespread across the U.S. south (Gallagher et al., 2006). The only assessment of logging truck drivers was done by Carnahan (2004), who found that self-rated safety and perceptual-motor scores were significantly related to moving violations, but not to crash involvement. Survey responses of logging truck drivers across the southeast U.S. indicated that factors such as age, experience, attitudes about regulations, and miles driven per year indicated generally low crash risk (Gallagher et al., 2006).

The objective of this review is to examine whether lecture-based training programs for logging truck drivers may be effective in reducing crash risk related to human factors. The scope of the review was restricted to training of commercial drivers and advanced driver training where a significant component of the training was an in-person or technology-based presentation. Commercial driver training research mainly addresses driver fatigue, aspects of situational awareness, and driver violations or behavior. To evaluate whether the training interventions had potential for improving performance, both information about the measurement of training outcomes (Tannenbaum et al., 1993) and factors related to training adoption (Colquitt et al., 2000) were considered.

Materials and Methods

Studies were identified through searches in Google Scholar and PsycInfo using search terms “driver” and “train(ing)”. Studies in which the intervention included technology-based or in-person training and involved professional drivers were included in the review. The literature cited in the identified studies was reviewed to find earlier literature. We were interested in the general topic category, type of intervention, evaluation typology, quantitative or qualitative outcomes, and other factors assessed by the study that could be related to training adoption. Additionally, we looked for evidence of training adoption by logging companies to examine the potential effectiveness of driver training in changing driver behavior or outcomes.

Results and Discussion

Human Factors and Driving

Human cognitive factors are probably more important than physical capacities in crash risk (MacDonald, 1985; Wang et al., 2016). While lecture-based training addresses human factors in crash causation, as identified by Treat et al. (1979), behind-the-wheel (BTW) or simulator training is designed to improve specific skills or reduce performance errors. However, Treat et al. (1979) and Najm et al. (1994) attributed a relatively small proportion of crash causation to performance errors or critical non-performance. Performance errors might be analogous to action errors, which include all failures due to inaction, delayed action, or incorrect action (Stanton and Salmon, 2009).

Recognition errors and decision errors were associated with most crashes (Treat et al., 1979; Najm et al., 1994). Among recognition errors are observation errors, which include

failures in the process of observation, such as failure to see a vehicle approaching an intersection (Stanton and Salmon, 2009). These errors could be related to the scanning behaviors that differentiate novice drivers from experienced drivers (Underwood, 2007). Cognition and decision-making errors involve, in part, the mental models that drivers create to perceive hazards and develop situational awareness. Intentional violations result from deliberate actions, but unintended driving violations may result from other types of error. The difference is between choosing to speed versus not recognizing a change in speed limit. Parker et al. (1995) indicated that the tendency to commit deliberate violations was more important in accident liability than lapses or errors.

Driver Training

Most new drivers complete some form of training prior to taking the CDL exam. However, sources have indicated that entry-level training is insufficient to ensure driver competence (Knipling et al., 2003; Chen et al., 2015; Gargoum et al., 2017). A review by Brock et al. (2007) found little research on driver training, and the principle measure of the effectiveness of entry-level training was the CDL exam. Perceived needs for standardized training led to the proposal of federal minimum standards for training for all new CDL holders planned for 2020 (Crissey, 2019) and now postponed until 2022. This effort could result in more consistent outcomes from CDL training due to specific training topics, certification of programs, and qualification of trainers.

Even drivers with a CDL are trained by their company with a combination of lecture, simulator, and BTW training. Nearly all carriers surveyed by Brock et al. (2007) believed that lecture training was effective, but the effectiveness ratings were higher for active learning and practice in the form of BTW training (over the road and range) and driving demonstrations than for lecture training. Staplin et al. (2004) identified several examples of research results and carrier-based training programs that positively affected the outcomes (number of driver violations) or results (reduced crash rates or rate of return).

Fleet managers were surveyed about driver management, and most had training programs for new hires (Knipling et al., 2003). For fleet safety management, training was rated as less effective than hiring and recruiting, safety behavior monitoring or evaluation, and preventative maintenance programs. Training may be designed to narrow the skills gap because recruiting drivers who are already qualified is difficult. Safety managers may attempt sustained training in addition to initial training to remind drivers about expected behaviors (Lueck and Murray, 2011). Hickman et al. (2007) found that the most frequent driver training topics mirrored crash factors such as inattentiveness, speeding, and following too close, and that nearly all the carriers they surveyed had entry-level training for specific driving and non-driving behaviors. Gargoum et al. (2017) indicated that drivers and transportation industry personnel were interested in BTW training to enhance driving skills, but they also prioritized training for vehicle-related issues, such as performing pretrip inspections and securing cargo.

Fatigue

Fatigue is described as a state of diminished alertness that may affect driver performance in both cognitive and physical tasks and is a contributing factor in large truck crashes (Gander et al., 2006) or close calls (Morrow and Crum, 2004). Even for local and short-haul transportation similar to logging, fatigue is an important factor in critical incidents (Hanowski et al., 2003). New federally mandated training curricula for entry-level commercial drivers includes fatigue management and rules for hours of service. The occurrence of

driver fatigue has several components: work scheduling or driver management, the nature of driving, personal behavior or habits, and awareness of fatigue. Fatigue countermeasures employed by drivers are often ineffective (Sallinen et al., 2014), and training may improve outcomes. Training topics to reduce fatigue while driving include information about personal habits that lead to better rest, coping strategies to deal with fatigue, and procedures to help recognize indicators of fatigue while driving.

Training on topics related to fatigue had significant effects in most of the studies identified. Following a lecture on aspects of fatigue, including physiology, management, impact, and company policies, participants showed significant knowledge gain from pre- to post-training exams (Gander et al., 2005). Reaction surveys showed that most participants felt the program was useful, but self-reported behavior change was limited to 50% or less. Gander et al. (2005) indicated that another outcome of fatigue training was a change in the culture of the organization. A safety culture was a contributor to reducing fatigue-related incidents (Strahan et al., 2008). Smiley et al. (2009) reported positive results from a fatigue management program that included driver management practices, driver health screening, corporate culture, and training. Machin (2003) described an active learning program designed to improve coping strategies and found that drivers reported an intention to implement the strategies and an increase in self-efficacy. Pylkkönen et al. (2018) found that a lecture combined with active learning and goal setting had some effect on the use of countermeasures but had no effect on outcomes that measured fatigue. While only one of the studies had information on fatigue training results, in a crash causation study, drivers in western Australia who completed fatigue management training had a lower odds ratio of crash involvement than drivers who did not complete the training (Meuleners et al., 2015).

The complex relationships among driver health, physical fitness, and crash risk were explored by Crizzle et al. (2017), and the relationships might indicate effective training interventions that would address fatigue. Obesity is related to fatigue through its contributions to health, physical fitness, and sleep disorders (Krueger et al., 2007). Health and wellness programs often have components of training and individual support, and companies that offer these programs indicate that crash prevention is one of the main objectives (Lemke and Apostolopoulos, 2015). A program that involved training, competition, and coaching was successful in weight loss and behavior change in a truck driver population (Olson et al., 2016). While the weight loss was thought to be meaningful, the indicators related to fatigue did not change.

Situational Awareness

Situational awareness is related to the perception of elements of the environment and comprehension of their meaning in the near future (Endsley, 1995). Situational awareness involves a number of cognitive skills to select and recognize aspects of the environment and access working memory. Improvements in situational awareness might be related to greater mental workload for advanced drivers when the situation becomes more complex. Drivers with better situational awareness have different scanning behavior and might have different, more complex mental models of potentially hazardous situations (Underwood, 2007). Hazard or risk perception may be improved with training and experience (McKenna and Crick, 1994; Wallis and Horswill, 2007). Driver training consisting of classroom training and coaching was able to improve recognition of, and connections among, aspects of the driving environment (Walker et al., 2009). Rogers et al. (1996) found that training in scanning patterns improved driver performance regardless of additional interventions.

Driver Behavior

There is considerable evidence that driver behavior, as indicated by traffic violations and previous crashes, is related to potential crash involvement (Lueck and Murray, 2011). Behavior-based safety training relies on observations of behavior to develop training and encourage lower-risk behaviors. Personalized coaching and driving data were able to reduce the incidence rate for a small group of drivers (Wang et al., 2018). Hickman and Geller (2005) studied a behavior-based safety training program with performance feedback focused on extreme braking and speeding. The behaviors changed during the intervention but returned to baseline levels afterward, indicating the importance of self-management over training. Huang and Ford (2012) explored whether safe behaviors might be promoted by internal versus external locus of control, increasing the importance of the driver's own knowledge and skill in accident avoidance. An internal locus of control is thought to be related to a greater link between behaviors and outcomes or a focus on internal, controllable causes versus external, uncontrollable causes. The researchers used a classroom defensive driving course to measure changes in locus of control, self-efficacy, and training behavior. Improved post-training performance was related to motivation to learn, self-efficacy, and change in locus of control from external to internal.

Driver compliance with regulations is measured through a compliance, safety, and accountability (CSA) program and reported as a behavioral analysis and safety improvement category (BASIC) score. Driver knowledge about the impacts of violations and crash involvement on BASIC scores might have contributed to changes in the type of violations and convictions related to crashes (Lueck, 2011). Improving knowledge about the impact of behaviors on driver safety (BASIC) scores might help reduce those behaviors.

Driver Training Effectiveness

All of the reviewed studies except Gander et al. (2005) included more interventions than a lecture or active learning exercise. At the most basic level, feedback or coaching gave the trainees more interaction with the content, increasing the likelihood of retention and potentially enabling adoption by the trainees. The ability to practice or receive information in more training modes would also support training objectives. A combination of interventions resulted in strong to modest changes in training behavior and in job behavior across a range of training topics. Two of the studies reported significant changes (weight loss and increased sleep) related to training programs. Six of the studies reported job behavior changes, but half of those were self-reports, which are difficult to evaluate without other information (Chao and Lam, 2011). Change in training behavior was documented in three of the studies. While adoption of training behavior is a critical step for the adoption of job behavior, a number of factors are important in this transition (Colquitt et al., 2000). Declarative knowledge was assessed as a component of fatigue training immediately after the training in three cases, and one of those added a delayed assessment. Three of the fatigue training studies incorporated a reaction component, which revealed some commitment to adopt the introduced behaviors. About one-third of the studies measured an attribute (e.g., valence, self-efficacy, motivation to learn, and locus of control) linked to training adoption. Among those attributes, self-efficacy and motivation had the most significant relationships to training adoption (Colquitt et al., 2000; Sitzmann and Ely, 2011).

Logging Company Training

Hiring, training, and monitoring of logging truck drivers are the responsibilities of logging companies that typically employ or contract a small number of drivers and loggers.

The effectiveness of logger training for logging tasks, at the industry and company level, is relevant to the expectations for the effectiveness of logging truck driver training. Most studies of logger training are recent because Doolittle (1990) found few studies related to training effectiveness or adoption in logging. More recently, Logan et al. (2015) identified 30 studies documenting the training of forest workers, logging employees, and logging company supervisors or contractors. Many of the logger training studies evaluated the adoption of training by contractors for practices at specific operations. For contractors, factors in the adoption of training include the perceived value, adequate technical skills, and knowledge for implementation. Statewide logger training initiatives have been supported by the SFI to demonstrate environmental compliance regarding voluntary best management practices for water quality protection and conservation of biodiversity and to reduce injury and fatality rates in logging (Clatterbuck and Hopper 1996; Germain and Harris, 2003). Compliance inspections related to SFI may play a role in the adoption of training. In that context, rates of self-reported adoption (Wightman and Shaffer, 2000; Helmkamp et al., 2004; Egan, 2005; Barrett et al., 2012; Berumen-Flucker et al., 2019) and intent to adopt (Reeb, 1996) among contractors could be expected. Job behavior and results are more difficult to measure, and documented training effects are mixed (Davis and Clatterbuck, 2003; Bell and Grushecky, 2006; Mujuru et al., 2009; Alonge, 2013).

While the evidence for training results is limited, there is a reasonable expectation that well designed in-person or distance education would be effective in influencing job behavior when accompanied by a company safety culture, support of the trained behavior by coworkers and supervisors, and surveillance of the trained behavior (Tracey et al., 1995). Studies have supported the need for an improved safety culture in logging (Gibson, 1994; Conway et al., 2017; Lagerstrom et al. 2017) to encourage positive behaviors (Burt et al., 2009). There is relatively little information about the safety culture of logging companies, and Lagerstrom et al. (2019) indicated variability in the perceptions of safety based on the harvesting system and worker experience, injury, and position. Individually, loggers emphasize the importance of individual errors in hazard exposure rather than safety systems, programs, or policies (Gibson, 1994; Conway et al., 2017). The perception of risk-taking and fatalism among loggers, as described by several authors (Ewing, 1992; Lawson, 2009; Patterson, 2008), is probably accurate, but with significant differences among companies (Reisinger et al., 1994; Wright et al., 2000; Montorselli et al., 2010).

As factors in training adoption, the actions of contractors and supervisors before and after training may be as significant as the drivers' reaction to the training (Salas et al., 2012). It is often assumed that a needs assessment has been completed prior to training design, and individual assessments will help match trainees with appropriate training content or methods. Following training, debriefing or reinforcement can help to develop goals for adoption and overcome barriers. Evaluation by the training program and the trainees' organizations using Kilpatrick's typology (reaction, knowledge, behavior, and results) will provide feedback to both the trainees and the organization about the training objectives. Evidence indicates that logging companies, as well as other small companies, struggle to develop and implement systems to monitor performance (Lepage and Lebel, 2007), which are part of the evaluation process. Michaelsen (2003) indicated the importance of management actions, including goal development and monitoring in addition to training, in the development of a program for improving the fuel efficiency of logging trucks.

Conclusion

Face to face, lecture, or online training along with other interventions can be effective in changing job behavior for at least three factors associated with crash risk: fatigue, situational awareness, and behavior. The frequency of defensive driver training is an indicator of the utility of training in situational awareness. For driver behavior, training success has been related to identifying a small group of related behaviors, providing specific training, and supporting adoption of the training. The implication is that training should be narrowly focused on the behaviors to be supported or changed. Fatigue management potentially requires modification of on-job and off-job behaviors, which is a significant challenge for contractors. However, drivers have some individual control of their adoption of fatigue training. Driver knowledge of the effects of fatigue and fatigue management strategies are sufficient for some positive benefit, with even greater benefit from contractor support.

To achieve the desired increase in qualified drivers and reductions in crash risk and insurance costs, logging contractors need the behavior changes and results to be measurable. For individual logging contractors, there is some doubt about whether the results of training will be measurable because changes in risk may not be detectable in a small number of drivers, and it is unlikely that every driver in a small group will benefit from the training. There may also be limited resources to improve training adoption through needs assessment, reinforcement, and monitoring.

Training programs for logging truck drivers in the form of lectures, videos, written material, and more recently online training have been offered by state and national forest industry organizations. However, the desired results will probably require more interventions than the creation and dissemination of training. The most important interventions are skills assessments, training reinforcement, and monitoring and feedback. Conducting skills assessments and providing reinforcement of trained behavior requires the development of these specific skills as well as domain knowledge among supervisors and contractors.

The most challenging aspect is monitoring and feedback of the results for training evaluation and revision. Crash incidence or enforcement results are likely too infrequent for successful monitoring at the company level, so contractors must translate expected training behaviors into attributes that can be measured. Passive monitoring of some behaviors (e.g., speeding, deceleration) are possible, but most trained behaviors require some form of self-reporting or active surveillance. Achieving the scale necessary to detect the effect of training on job behavior may require aggregating data from many companies or training participants. This large-scale feedback may give insurance providers a better sense of the change in risk and provide information for revising the training.

While definitive surveys of the safety culture in logging companies are lacking, the available information suggests that a supportive safety culture, which is important for training adoption, is not widespread. Historically, training opportunities have been targeted at company owners and supervisors, with more limited opportunities for formal training of workers (loggers or drivers). Large-scale training of new and existing logging workers have gained industry support. With perceived shortages of qualified employees, several training programs for new logging workers and logging truck drivers have been started across the U.S. in the last five years (FRA, 2020). These changes may indicate broader support for training in the logging industry.

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