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Truck driver reported unrealistically tight delivery schedules linked to their opinions of maximum speed limits and hours-of-service rules and their compliance with these safety laws and regulations

Guang X. Chen[a,*], **W. Karl Sieber**[b], **James W. Collins**[a], **Edward M. Hitchcock**[c], **Jennifer E. Lincoln**[a], **Stephanie G. Pratt**[a], **Marie H. Sweeney**[b]

[a]Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research, Morgantown, WV, USA

[b]CDC, NIOSH, Division of Field Studies and Engineering, Cincinnati, OH, USA

[c]CDC, NIOSH, Division of Science Integration, Cincinnati, OH, USA

Abstract

Objectives: The study objectives were to examine U.S. long-haul truck drivers (LHTDs)' opinions on their safety needs and to assess the associations of driver reported unrealistically tight delivery schedules with: (1) their opinions on their compensation, maximum speed limits, and Hours-of-Service (HOS) regulations, and (2) their behaviors of noncompliance with these safety laws and regulations.

Methods: National Institute for Occupational Safety and Health analyzed data from its 2010 national survey of LHTD health and injury. A total of 1,265 drivers completed the survey. Logistic regression was used to examine the associations between driver reported unrealistically tight delivery schedule and their opinion on safety and unsafe driving behaviors.

Results: Drivers who reported often receiving an unrealistically tight delivery schedule (an estimated 15.5% of LHTDs) were significantly more likely than drivers who reported never receiving an unrealistically tight delivery schedule to report that: (1) increasing the current maximum speed limit on interstate highways by 10 miles per hour (mph) would improve safety (odds ratio (OR) = 2.1); (2) strictly enforcing HOS rules would not improve safety (OR = 1.8); (3) they often drove 10 mph or more over the speed limit (OR = 7.5); (4) HOS regulations were often violated (OR = 10.9); (5) they often continued to drive despite fatigue, bad weather, or heavy traffic because their must delivery or pick up a load at a given time (OR = 7.5); and (6) their work was never adequately rewarded (OR = 4.5). When presented with 11 potential safety strategies, the largest percentage of LHTDs (95.4%) selected that building more truck stops/parking areas would improve truck driver safety.

Conclusions: Driver reported unrealistically tight delivery schedules are associated with drivers' beliefs in safety laws/regulations and risk-taking behaviors. LHTDs see building more truck stops/

[*]Corresponding author at: Division of Safety Research, 1095 Willowdale Road, MS/1811, Morgantown, W.Va. 26505, USA. gchen@cdc.gov (G.X. Chen).

rest areas as the most wanted safety need among the 11 potential safety strategies that were asked about in the survey.

Keywords

Delivery schedules; Truck drivers; Truck safety; Driver opinions; Driver behaviors; Survey

1. Introduction

Truck transportation is essential to the United States (U.S.) economy, with over 70% of the domestic freight tonnage moved in the U.S. transported by trucks (ATA, 2016). There were approximately 2 million heavy and tractor-trailer truck drivers in the United States in 2018, the majority of whom were long-haul truck drivers (LHTDs) who deliver goods over intercity routes that may span several states (BLS, 2020). These drivers face a high risk of truck crashes and occupational injuries. They were 12 times more likely to die on the job (Chen, et al., 2014) and 3 times more likely to suffer an occupational injury requiring days away from work than the general U.S. worker population (BLS, 2017). In the United States, large truck occupant deaths due to truck crashes continue to rise and were at their highest level in 28 years in 2017: there were 4,761 large truck fatalities and among them 841 were large truck occupants (FMCSA, 2020a). Fatal crashes involving large trucks and buses costed the U.S. economy an estimated $51 billion in 2017, and the economic impact escalated to $135 billion, when crashes with injuries or property damage are included (FMCSA, 2020a). The National Transportation Safety Board (NTSB) found fatigue to be the most frequently cited probable cause (31%–40%) in fatal-to-the-truck-driver crashes (NTSB, 1990; Marcus and Rosekind, 2017). The Federal Motor Carrier Safety Administration (FMCSA)'s Large Truck Crash Causation Study estimated that 13% of all fatal large-truck-related crashes involved fatigue as either a primary or secondary factor (FMCSA, 2007). The NTSB (2020) has listed the reduction in fatigue-related crashes as one of the most critical changes needed to reduce transportation accidents and save lives for 2019–2020.

Truck drivers operate in a work environment with a number of factors that can be associated with increased fatigue and stress because they can be away from home for days or weeks at a time; have long work hours, irregular work schedules, and time pressured delivery schedules (Sieber, et al, 2014; BLS 2020); are required to wait for access to a loading dock; are stuck in traffic (Chen et al., 2015b; FMCSA, 2007, Bunn et al., 2009, 2005; Stevenson et al., 2010); and are paid by miles driven instead of by hours worked (Belzer, 2012; Belzer and Rodriguez, 2002;.Quinlan and Wright, 2008). Some drivers must load and unload cargo themselves (BLS, 2020; Sieber et al., 2014). Some of these work conditions are similar across countries, such as long work hours, irregular work schedule, time pressured delivery schedules, and pay determined by miles driven instead of by hours worked (Bigelow et al., 2012; Brodie et al., 2009; Haworth et al., 1991; Jun and Bensman, 2010; Quinlan, 2003; ILO, 2000; 2015; Haworth, et al., 1991; Kircher and Andersson, 2013; Sabbagh-Ehrlich et al., 2005).

Studies of the association between work conditions and truck driver safety have focused on the impact of long work hours and irregular work schedules on driver sleep, driver fatigue,

and safety critical events (SCEs). Studies suggested that long work hours and irregular work schedules reduced drivers' sleep duration and sleep quality (Heaton et al., 2008; Hege et al., 2015; Apostolopoulos et al., 2010; 2014, Hanowski et al., 2007). Researchers using naturalistic truck driving data analyzed the impact of time-on-task on safety critical event risk and found no consistent significant difference in risk of SCEs between hours 2 through 11 (Hanowski et al., 2009). Few studies have assessed the association between the impact of time pressured delivery schedules on truck driver safety. A study by Braver et al. (1999) who examined factors that determined truck driver work schedules and found that 75% of dispatchers reported that they would consider revenue as a factor to determine whether to accept/reject a load compared to 9% of dispatchers who reported that they would consider HOS status as a factor. However Braver's study did not examine the association between time pressured delivery schedules and truck driver safety. Our literature review revealed that not much has been reported on the effect of schedule pressure on safety and what has been reported is mostly concentrated on the construction industry (Nepal et al., 2006; Han et al., 2014). Han and his colleagues (2014) referred to schedule pressure as production pressure. They concluded that production pressure was a key linkage between scheduling and safety in the construction industry. A Netherland driving stimulator study of 54 participants (who were university employees and students) suggested that under time pressure in comparison to non-time pressure, participants drove significantly faster and exhibited increased physiological activities, such as heart rate, respiration rate, and pupil diameter (Rendon-Velez and Happee, 2016). In 2019, the New York Time reported a fatal delivery truck crash that might be due to a time pressured delivery schedule (Callahan, 2019). No epidemiological study has been reported so far on the association between time pressured delivery schedules and truck driver safety.

The NIOSH long-haul truck driver survey suggested that 37% of LHTDs reported that HOS regulations were often or "sometimes" violated, 31% reported they often or sometimes drove 10 miles per hour (mph) over the speed limits, and 71% reported they often or sometimes continued to drive despite fatigue, bad weather, or heavy traffic because they must deliver or pick up a load at a given time (Chen et al., 2015). An Austrian truck driver survey also suggested that approximately 5% of respondents reported that almost every trip they continue driving even when on the edge of falling asleep. The research question is why drivers do what they do. The U.S. National Academia of Sciences, Engineering, and Medicine (2016) recommended that FMCSA should support research aimed at better understanding the factors associated with driver behavior related to fatigue and sleep deficiency, including what motivates drivers' decisions about whether to continue driving when they feel fatigued. An example of such research is the recent reports, by Belzer and his colleagues, suggesting that LHTDs work extremely long hours because they work for the money (Belzer and Sedo, 2018; Kudo and Belzer, 2019). Compared to LHTDs with a lower pay rate, LHTDs with a higher pay rate work fewer hours and are less likely to have fatigue.

The study's objectives were to examine U.S. LHTDs' opinions on their safety needs and to assess the associations of driver reported unrealistically tight delivery schedules with: (1) their opinions on their compensation, maximum speed limits, and HOS regulations, and (2) their behaviors of noncompliance with these safety laws and regulations.

2. Methods

2.1. Study population and survey methods

Data for this study were collected as part of the National Institute for Occupational Safety and Health's (NIOSH) National Survey of LHTD Health and Injury. The survey was a nationally representative sample of 1265 U.S. LHTDs participating at 32 truck stops along selected interstate highways across the contiguous United States in 2010. LHTDs were eligible for the survey if they had driven a truck with three or more axles as their main job for at least 12 months and took at least one mandatory 10-hour rest period away from home during each delivery run, as mandated by the FMCSA (FMCSA, 2003). A complex three-stage sampling process was used to achieve the best possible nationally representative sample of LHTDs: (1) first selection of interstate or other limited-access highway sections. Limited-access highway segments were stratified by geographic region and truck traffic volume; (2) followed by selection of individual truck stops along the selected highway sections. Truck stops with a restaurant and paved overnight parking lot with at least five parking spaces were identified using a national listing of truck stops [Brice, 2008]. Thirty-two truck stops were selected with probability proportional to the number of parking spaces at the truck stop; and (3) random selection of drivers for interview at the selected truck stops. Additional information on the sampling methods are available in the previous report by Sieber et al (Sieber et al., 2014). The survey was approved by the NIOSH Human Subjects Review Board. The questionnaire used in the survey was developed with input from a stakeholder meeting and two LHTD focus group discussions. Participants in the stakeholder meeting included representatives from the American Trucking Associations (ATA), Owner Operator Independent Drivers Association, trucking companies, unions, FMCSA, academia, and other truck and highway safety organizations. The questionnaire was pilot tested at truck stops with LHTDs.

2.2. Data collected

The in-person, interviewer-administered survey collected data on broad aspects of truck driver health and injury, including demographic information, employment history, working conditions, job compensation, driver training, health conditions, truck crashes, occupational injuries, drivers' opinions of their safety needs, and driving behaviors (Sieber et al, 2014; Birdsey et al, 2015; Chen et al, 2015a; 2015b). From a list of 11 potential safety strategies, drivers were asked to rate how well each strategy would improve the safety of truck drivers, using a Likert scale from 0 ("not at all") to 5 ("very much"). For this analysis, drivers' ratings were collapsed into two categories: "low level of agreement" (response choices 0–2), and "high level of agreement" (3–5). Reasons for the collapsing into two categories include easy interpretation and understanding of the results. Like all other questionnaire items, the list of 11 potential safety strategies which were listed in Table 2 was informed by input from a stakeholder meeting and two focus group discussions with LHTDs.

There were three response categories (often/sometimes/never) for questions such as: (1) How often do you receive an unrealistically tight delivery schedule? (2) How often do you continue to drive despite fatigue, bad weather, or heavy traffic because you must deliver or pick up a load at a given time? (3) How often do you drive 10 miles or more faster than the

speed limit? and (4) How often do you feel your work has been adequately rewarded in the past 12 months?

2.3. Statistical analysis

Descriptive statistical methods were used to assess national estimates for LHTDs' opinions on their safety needs from the 11 potential safety strategies. To compute the national estimates, each completed personal interview was assigned a probability weight which represented the inverse of the product of probabilities of selection of the highway segment in stage 1, the truck stop in stage 2, and the truck driver in stage 3:

$$\text{Weight} = [\text{Probability(highway segment)} * \text{Probability(truck stop)} * \text{Probability(truck driver)}]^{-1}$$

The national estimates of the total number of LHTDs and percentages of drivers responding to individual interview questions were determined as the sum of the probability weights for responding truck drivers.

Logistic regression analyses were performed to assess the associations between drivers' opinions and potential risk factors. For this purpose, three separate regressions were used. (1) Opinion of whether their work was adequately rewarded was used as the dependent variable (never vs. often); age, gender, driver reported frequency of receiving unrealistically tight delivery schedules, and annual income were used as independent variables. (2) Opinion of whether increasing the current speed limit on interstate highways by 10 mph would improve safety was used as the dependent variable (high level of agreement vs. low level of agreement); age, gender, and driver reported frequency of receiving unrealistically tight delivery schedules were used as independent variables. (3) Opinion of whether strictly enforcing the HOS regulations would improve safety was used as the dependent variable (low level of agreement vs. high level of agreement); age, gender, and driver reported frequency of receiving unrealistically tight delivery schedules were used as independent variables.

Logistic regression analyses were also performed to assess the associations between driving behaviors and potential risk factors. For this purpose, three separate regressions were used. (1) Driver reported frequency of driving 10 mph or more over the speed limit was used as the dependent variable (often vs. never); age, gender, driver opinion on whether increasing current speed limit on interstate highways by 10 mph would improve safety, and driver reported frequency of unrealistically tight delivery schedules were used as independent variables. (2) Driver reported frequency of continuing to drive despite fatigue, bad weather, or heavy traffic because they must deliver or pick up a load at a given time was used as the dependent variable (often vs. never); age, gender, driver reported frequency of unrealistically tight delivery schedules, and annual income were used as independent variables. (3) Drivers reported violating HOS rules was used as the dependent variable (often vs. never); age, gender, driver reported frequency of unrealistically tight delivery schedules, and annual income were used as independent variables. The dependent variables for these three logistic regressions had three response categories (often/sometimes/never). In the logistical regressions, drivers who reported "sometimes" were excluded from the

analysis. This exclusion was made because the goal of this study is to compare the group who reported “often” with the group who reported “never.” All statistical analyses were performed using SAS 9.4 (SAS, 2013).

3. Results

The NIOSH long-haul truck driver survey suggested that U.S. LHTDs had a mean age of 47.8 years, 93.5% of LHTDs were male, 64.5% were company drivers, and 35.5% were owner-operators (Sieber et al, 2014). Additional results of U.S. LHTDs’ demographic information and employment history are available in previous reports (Sieber et al. 2014; Birdsey et al 2015; Chen et al 2015b). Table 1 lists results of driver reported unrealistically tight delivery schedules, driving behaviors, and driver opinion of their job compensation. These data are also available from Chen et al., 2015b.

When presented with 11 potential safety strategies, LHTDs most often reported high level of agreement (i.e., reported a 3–5 on the Likert scale) with building more truck stops/parking areas would improve truck driver safety (95.4% of LHTDs), followed by equally enforcing traffic laws on car and truck drivers (90.5%), paying drivers by the hour for loading and unloading time (87.7%), and equalizing maximum speed limits for cars and trucks on interstate highways (86.6%). Only 10.8% reported high level of agreement with decreasing the current maximum speed limit on interstate highways by 10 mph would improve safety (Table 2).

Table 3 lists results of the three logistic regression models that used drivers’ opinions of their job compensation, maximum speed limits, and HOS rules as the dependent variables. (1) In model one, drivers’ opinion on “whether their work was adequately rewarded” was used as the dependent variable. Compared to drivers who reported never receiving an unrealistically tight delivery schedule, those who reported often receiving an unrealistically tight delivery schedule were significantly more likely to report their work was never adequately rewarded (odds ratio (OR) = 4.5). (2) In model two, drivers’ opinion on “whether increasing the speed limit on interstate highways by 10 mph would improve safety” was used as the dependent variable. Compared to drivers who reported never receiving an unrealistically tight delivery schedule, those who reported often receiving an unrealistically tight delivery schedule were significantly more likely to have high level of agreement with the statement that increasing the current maximum speed limit on interstate highways by 10 mph would improve safety (OR = 2.1). (3) In model three, drivers’ opinion on “whether strictly enforcing the HOS regulations would improve safety” was used as the dependent variable, compared to drivers who reported never receiving an unrealistically tight delivery schedule, those who reported often receiving an unrealistically tight delivery schedule were significantly more likely to report low level of agreement with the statement that strictly enforcing the HOS rules would improve safety (OR = 1.8).

Table 4 lists results of the three logistic regression models that used drivers’ unsafe driving behaviors (speeding, continuing to drive despite adverse conditions, and violating HOS rules) as the dependent variables. (1) In model one, “driver reported frequency of driving 10 mph or more over the speed limit” was used as the dependent variable (often vs.

never). Compared to drivers who reported never receiving an unrealistically tight delivery schedule, those who reported often receiving one were significantly more likely to report often speeding (OR = 7.5). (2) In model two, “driver reported frequency of continuing to drive despite fatigue, bad weather, or heavy traffic because they must deliver or pick up a load at a given time” was used as the dependent variable (often vs. never). Compared to drivers who reported never receiving an unrealistically tight delivery schedule, those who reported often receiving one were significantly more likely to report often continuing to drive despite fatigue, bad weather, or heavy traffic (OR = 7.5). (3) In model three, “driver reported frequency of violating HOS rules” was used as the dependent variable (often vs. never). Compared to drivers who reported never receiving an unrealistically tight delivery schedule, those who reported often receiving one were significantly more likely to report often violating HOS rules (OR = 10.9).

4. Discussion

4.1. Safety needs from LHTDs’ perspective

The NIOSH survey suggested that among the five safety needs identified by most LHTDs, two (build more truck stops/parking areas and designate truck-only lanes on interstate highways) would require changes in infrastructure, and the other three (equal speed limits and equal enforcement of traffic laws on cars and trucks, and strictly enforcing HOS regulations) would require changes in laws and policies.

The need for additional truck stops and parking areas has been identified by several governmental and industry studies (NTSB, 2000; FHWA, 2002; 2015; ATRI, 2016). This study suggested that building more truck stops and parking areas was the most wanted safety need by LHTDs (identified by the highest percentage (95.4%) of LHTDs) among many needs. A recent study by Bunn et al. (2017) indicated there was an association between commercial vehicle driver at-fault crashes involving sleepiness/fatigue and proximity to rest areas or truck stops. There was an inverse relationship between the risk of commercial vehicle driver at-fault crashes and the distance between the crash site and location of rest areas or truck stops. Their study results suggested that infrastructure changes including more truck stops and parking areas could potentially result in increased safety.

The second most wanted safety need by LHTDs (identified by 90.5% of LHTDs) was strictly enforcing existing traffic laws on car and truck drivers equally. Previous analysis of the LHTD survey by Chen et al. (2015b) found that 90.2% of LHTDs reported “often” (36.1%) or “sometimes” (54.0%) getting frustrated by drivers of passenger vehicles on the road. These results suggested a need for educating the public on how to share the road with commercial heavy trucks. FMCSA (2016) launched a new safety campaign “Our Roads, Our Responsibility” to raise awareness about sharing the road with large trucks and buses. LHTDs also favored the idea of truck-only lanes on the interstate highways. Truck-only lanes are lanes designated for the use of trucks. Trucks are required to use truck-only lane while passenger cars are encouraged not to use the truck-only lanes but not prohibited. The purpose of truck-only lanes is to separate trucks from other mixed-flow traffic to enhance safety and/or stabilize traffic flow. There have been a few studies and discussions on the feasibility and potential safety benefit of building truck-only lanes on interstate highways in

California and Oregon. The potential benefits may include making interstate highways less congested and safer for both truck and passenger vehicle drivers by not sharing the road between truck and passenger vehicle drivers (FHWA, 2005; Lord, et al, 2009; ODOT, 2009; myAJC, 2016; CA.gov, 2017).

Paying drivers by the hour for loading and unloading time is among the top 5 most wanted safety needs identified by LHTDs. Researchers and organizations have also recommended better pay (including paying drivers by the hours worked) for better truck safety in the United States and Australia (Belzer and Rodriguez, 2002; Belzer, 2012; Belzer and Sedo, 2018; Quinlan and Wright, 2008; Quinlan, 2016; Thompson and Stevenson, 2014). There are several factors that may influence drivers' compensation: (1) whether drivers are paid by the miles or by the hours; (2) whether they are paid for loading, unloading, and waiting time; (3) what their actual rate of pay might be; (4) what is the driver's targeted earning (Belzer and Sedo, 2018), (5) whether there is a driver shortage, and (6) truck drivers are exempt from overtime pay under the Fair Labor Standards Act (BLS, 2009) in the United States. In 2015, U.S. Senate bill S.1739 - Truck Safety Act (https://www.congress.gov/bill/114th-congress/senate-bill/1739/text) included a provision requiring employers to pay truck operators for all hours worked, rather than solely per miles driven. However, this has not become a law and is making its way through the courts (https://www.trucks.com/2018/10/22/court-ruling-require-driver-pay/). Paying drivers for all hours worked would require federal legislation with support from the industry; or an independent industry-wide decision to change practices (Overdive, 2019). In addition to monetary compensation, the study's results suggested that driver reported unrealistically tight delivery schedule also influenced how they perceived their job being compensated.

In the United States, the median annual wage for heavy and tractor-trailer truck drivers was $45,260 in 2019 (BLS, 2020). The study's results of the associations between annual income and unsafe driving behaviors are mixed: compared to drivers with an annual income greater than $50,000, drivers with an annual income of $50,000 or less were more likely to report continuing to drive despite fatigue, bad weather or heavy traffic because they must deliver or pick up a load at a given time, but they were less likely to report often violating HOS regulations. One possible explanation is that drivers with an annual income of $50,000 or less were more likely to be younger drivers who may be willing to take more demanding delivery jobs compared to older or more senior drivers. On the other hand, lower income drivers might be unable to get the amount of work necessary to meet their needs, which might push them to work long hours beyond what is allowed by HOS regulations. Further research is needed to explain the mixed results.

4.2. The association of driver reported unrealistically tight delivery schedules and truck driver safety

Previous studies of truck driver work conditions and safety have focused on the association between work conditions and driver rest, sleep, and fatigue. An Australian truck driver survey suggested that about 20% of respondents reported that their employer did not give them enough time to stop to rest (Haworth et al., 2991). However, the Australian survey did not examine the association between time pressured schedule and truck drivers' opinions

of safety needs and unsafe driving behaviors. This study expanded the current literature by linking time pressured delivery schedules to driver's opinions on their safety needs and unsafe driving behaviors. The study's results suggested that driver reported unrealistically tight delivery schedules were not only linked to their low level of agreement with maximum speed limits and HOS regulations, but also to their behaviors of noncompliance with these safety laws and regulations. HOS regulations were issued by the Federal Motor Carrier Safety Administration (FMCSA). The regulations limit the number of daily and weekly hours a commercial vehicle driver can drive and work, and regulate the minimum amount of time a commercial vehicle driver must spend resting between driving shifts in the United States. Canada, Mexico, Australia, New Zealand, and the European Union have similar regulations.

In European countries and Australia, researchers developed programs that help carriers, dispatchers, shippers in scheduling a time sensible delivery schedule, to find a feasible delivery schedule that is flexible and can be configured to consider different sets of rules imposed by government regulations and union contracts (Goel, 2010; 2012; Goel et al., 2011). In North America, the North American Fatigue Management Program (www.nafmp.com) is a web-based training program and provides carriers and dispatchers a comprehensive approach to manage their delivery schedules.

Law enforcement and in-vehicle safety technologies, such as speed limiters (or speed governors) and in-vehicle monitoring systems (IVMS), can reduce unsafe driving behaviors. Vaa (1997) found that intensive enforcement (an average of 9 hours of police presence along a 35-kilometers long stretch of road per day) resulted in reductions in vehicle speed that lasted up to 8 weeks. Shinar and Stiebel (1986) demonstrated the relationship between the perceived risk of receiving a citation and driving in excess of speed limits. The researchers found compliance with speed limits to be greatest in the vicinity of police vehicles and diminish with increasing distance from policy vehicles; the distance halo effect was greater for mobile than stationary police vehicles. Companies can also use speed limiters or governors, which limit maximum vehicle speed, to reduce speed-relevant crashes. Hanowski et al. (2012) suggested that trucks equipped with speed limiters had a significantly lower rate of speed-relevant crashes (approximately 50% lower) compared to trucks without speed limiters. A NIOSH study (Bell et al., 2017) suggested that IVMS in conjunction with feedback plus supervisory coaching were effective in improving truck drivers' unsafe driving habits including speeding, cell phone use while driving, seatbelt use, fatigued driving, and distracted driving.

5. Limitations

The study limitations include that the current findings are dependent on the assumption that the survey respondents interpreted "unrealistically" tight delivery schedules in the same way. The self-reported data are subject to recall and interviewer bias. The survey respondents might have provided socially and legally appropriate answers to questions regarding speeding and HOS rules violation. Although this "social desirability" bias was minimized by the anonymous nature of this survey and by assuring respondents that results would be published only in aggregate form, results suggested the illegal statements regarding HOS

rules and driving 10 + miles over the speed limit were much less frequently reported than driving despite fatigue, weather, etc. which is not illegal. However, driver self-reported speeding, fatigued driving, and noncompliance with HOS were used in previous studies (Stephens, et al., 2017; Hege, et al., 2015; McCartt et al., 2008). Another limitation is that the questions to collect drivers' opinions of their safety needs might lead the respondents to answer positively. This is a cross-sectional study that cannot be used to infer causality because a temporal sequence cannot be established.

6. Opportunities for future research

One of the study limitations is that the current findings are dependent on the assumption that the survey respondents interpreted "unrealistically" tight delivery schedules in the same way. The emergence of onboard safety monitoring systems including real time fatigue measurement technologies and the mandatory use of the electronic logging device (ELD) in the United States (effective on December 16, 2019) provide new opportunities to measure time pressured delivery schedules, driver fatigue, and driving behaviors objectively. Future research is needed to study the impact of time pressured delivery schedules on truck driver safety by using these objective measurements. The onboard fatigue/behaviors measurement technologies use machine learning and pattern recognition technologies to detect driver fatigued and distracted driving behaviors. The technologies can also provide feedback to drivers and managers in real time, which can potentially reduce fatigued and distracted driving (Wang and Xu, 2015; Masala and Grosso, 2014). The U.S. FMCSA plans to employ data from onboard safety monitoring systems in its updated study of contributing factors to crashes involving large commercial trucks (FMCSA, 2020b).

7. Conclusions

The NIOSH national LHTD survey suggested that driver reported unrealistically tight delivery schedules were common among LHTDs. Driver reported unrealistically tight delivery schedules can erode drivers' beliefs in safety laws/regulations and promote risk-taking behaviors. LHTDs see building more truck stops/rest areas as the most wanted safety need among the 11 potential safety strategies that were asked about in the survey. These findings suggest where interventions may be considered. For example, (1) government and private partners can build more truck stops/rest areas; (2) carriers and dispatchers can adopt recommendations in the North American Fatigue Management Program (www.nafmp.com) and schedule delivery times so that drivers can have adequate time for sleep and rest; (3) drivers can be given training to inform them of the risks of noncompliance with the maximum speed limits and HOS rules; and (4) carriers can use speed limiters and IVMS with supervisor feedback to reduce unsafe driving habits.

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Table 1

[a]Results of LHTD reported unrealistically tight delivery schedules, driving behaviors, and opinion on their job compensation, National Survey of U.S. Long-Haul Truck Driver (LHTD) Health and Injury 2010.

Survey questions	Often (%[b])	Sometimes (%)	Never (%)
In your driving experience over the previous 12 months, how often do the following situations occur?			
You receive an unrealistically tight delivery schedule.	15.5	57.9	25.7
The hours-of-service rules are violated.	9.7	27.0	63.0
You continue to drive despite fatigue, bad weather, or heavy traffic because you must deliver or pick up a load at a given time?	23.8	47.0	29.2
You drive 10 miles per hour or more over the speed limit?	4.5	26.0	69.4
You feel your work has been adequately rewarded?	36.1	34.2	29.4

[a]: Source: Chen et al. (2015b). Results were based on responses from 1263 LHTDs.

[b]: Percent is weighted national estimate. Weighted national estimates were computed using all non-missing survey responses.

Table 2

National estimates of drivers' opinions on 11 potential safety strategies, National Survey of U.S. Long-Haul Truck Driver (LHTD) Health and Injury 2010.

Survey Question:	**Weighted national estimate**[a]	
I'm going to read you some activities that may or may not improve safety for truck drivers, using a scale from 0, which means "not at all," to 5, which means "very much." Please rate how well each statement describes how you feel about whether or not the activity would improve safety	High level of agreement[b] (%)	Low level of agreement (%)
Build more truck stops/parking areas	95.4	4.6
Strictly enforce traffic laws on car and truck drivers equally	90.5	8.8
Pay drivers by the hour for loading and unloading time	87.7	11.4
Equalize the car and truck maximum speed limit on interstate highways	86.6	13.3
Strictly enforce the hours-of-service (HOS) regulations	60.2	39.6
Designate truck only lanes on interstate highways	59.6	39.1
Pay drivers by the hour for driving time	53.0	46.2
Require a short rest break after 4 h continuous driving	43.9	55.6
Require speed governors for all large trucks	27.5	72.2
Increase the current maximum speed limit on interstate highways by 10 mph	26.2	72.8
Decrease the current maximum speed limit on interstate highways by 10 mph	10.8	88.6

[a]: Weighted national estimates were computed using all non-missing survey responses (1263).

[b]: The original response was a Likert scale from 0 ("not at all") to 5 ("very much"). For this analysis, the ratings of 0–2 were collapsed into "low level of agreement" and the ratings of 3–5 were collapsed into "high level of agreement."

Table 3

Results of the three logistic regressions that used drivers' opinions as the dependent variables, National Survey of U.S. Long-Haul Truck Driver Health and Injury 2010

Drivers' opinions (Dependent variables)	Risk factors (Independent variables)	OR (95% CI)[a]
Model one		
Opinion on whether their work was adequately rewarded (never vs. often)	Age[b]	0.99 (0.97–1.01)
	Gender (female vs. male)	1.1 (0.5–2.2)
	Reported frequency of receiving unrealistically tight delivery schedule (often vs. never)	4.5 (2.9–7.0) *
	Reported frequency of receiving unrealistically tight delivery schedule (sometimes vs. never)	2.4 (1.7–3.4) *
	Annual income, (<=$50,000 vs. >$50,000)	2.0 (1.5–2.7) *
	The Hosmer and Lemeshow test[c]: $\chi^2 = 10.1$ Pr > ChiSq = 0.3	
Model two		
Opinion on whether increasing the speed limit on interstate highways by 10 mph would improve safety (High level of agreement vs. low lever of agreement)	Age	0.99 (0.98–1.00)
	Gender, female vs. male	1.1 (0.7–1.8)
	Reported frequency of receiving unrealistically tight delivery schedule (often vs. never)	2.1 (1.4–3.1) *
	Reported frequency of receiving unrealistically tight delivery schedule (sometimes vs. never)	1.6 (1.1–2.1) *
	The Hosmer and Lemeshow test: $\chi^2 = 7.8$ Pr > ChiSq = 0.5	
Model three		
Opinion on whether strictly enforcing the HOS regulations would improve safety (Low lever of agreement vs. high level of agreement)	Age	0.99 (0.98–1.01)
	Gender (female vs male)	1.0 (0.6–1.6)
	Reported frequency of receiving unrealistically tight delivery schedules (often vs. never)	1.8 (1.2–2.5) *
	Reported frequency of receiving unrealistically tight delivery schedules (sometimes vs never)	1.5 (1.2–2.0) *
	Employment (owner-operators vs. company drivers)	1.8 (1.4–2.3) *
	The Hosmer and Lemeshow test: $\chi^2 = 5.1$ Pr > ChiSq = 0.7	

[a]: OR — odds ratio; CI — confidence interval.

[b]: Age was used as a continuous variable in the logistic regressions.

[c]: The null hypothesis for the Hosmer and Lemeshow test is that the data fit the model. P > 0.05 means that at $\alpha = 0.05$ we fail to reject the hypothesis that the data fit the model.

*: Significant at the 0.05 level.

Table 4

Results of the three logistic regression models that used drivers' driving behaviors as the dependent variables, National Survey of U.S. Long-Haul Truck Driver Health and Injury 2010.

Behaviors (dependent variables)	Risk factors (independent variables)	OR (95% CI)[a]
Model one		
Driver reported frequency of driving 10 mph or more over the speed limit (often vs. never)	Age[b]	0.98 (0.95–1.0)
	Gender (female vs. male)	0.6 (0.2–1.9)
	Opinion on whether increasing current speed limit on interstate highways by 10 mph would improve safety (High level of agreement vs. low level of agreement)	4.4 (2.6–7.3) *
	Reported frequency of unrealistically tight delivery schedule (often vs. never)	7.5 (3.2–17.8) *
	Reported frequency of unrealistically tight delivery schedule (sometimes vs. never)	1.9 (0.8–4.5)
	The Hosmer and Lemeshow test[c]: χ^2 = 6.5 Pr > ChiSq = 0.6	
Model two		
Driver reported frequency of continuing to drive despite fatigue, bad weather, or heavy traffic because they must deliver or pick up a load at a given time (often vs. never)	Age	0.981 (0.966–0.997) *
	Gender (female vs. male)	0.6 (0.3–1.1)
	Driver reported frequency of unrealistically tight delivery schedule (often vs. never)	7.5 (4.5–12.3) *
	Driver reported frequency of unrealistically tight delivery schedule (sometimes vs. never)	3.0 (2.0–4.5) *
	Annual income (<=$50,000 vs. >$50,000)	1.6 (1.2–2.2) *
	The Hosmer and Lemeshow test: χ^2 = 10.7 Pr > ChiSq = 0.2	
Model three		
Driver reported frequency of violating HOS rules (often vs. never)	Age	1.0 (1.0–1.0)
	Gender (female vs. male)	0.7 (0.3–1.5)
	Driver reported frequency of unrealistically tight delivery schedule (often vs. never)	10.9 (5.3–22.3) *
	Driver reported frequency of unrealistically tight delivery schedule (sometimes vs. never)	3.6 (1.8–7.1) *
	Drivers' opinion on whether strictly enforcing the Hours-of Service regulations would improve safety (low level of agreement vs. high level of agreement)	6.1 (4.0–9.3) *
	Annual income (<=$50,000 vs. >$50,000)	0.7 (0.4–0.99) *
	The Hosmer and Lemeshow test: χ^2 = 5.4, Pr > ChiSq = 0.7	

[a]: OR — odds ratio; CI — confidence interval.

[b]: Age was used as a continuous variable in the logistic regressions.

[c]: The null hypothesis for the Hosmer and Lemeshow test is that the data fit the model. P > 0.05 means that at $\alpha = 0.05$ we fail to reject the hypothesis that the data fit the model.

*: Significant at the 0.05 level.