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Crash risk factors for interstate large trucks in North Carolina

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ABSTRACT

Introduction: Provide an updated examination of risk factors for large truck involvements in crashes resulting in injury or death. *Methods*: A matched case–control study was conducted in North Carolina of large trucks operated by interstate carriers. Cases were defined as trucks involved in crashes resulting in fatal or non-fatal injury, and one control truck was matched on the basis of location, weekday, time of day, and truck type. The matched-pair odds ratio provided an estimate of the effect of various driver, vehicle, or carrier factors. *Results*: Out-of-service (OOS) brake violations tripled the risk of crashing; any OOS vehicle defect increased crash risk by 362%. Higher historical crash rates (fatal, injury, or all crashes) of the carrier were associated with increased risk of crashing. Operating on a short-haul exemption increased crash risk by 383%. Antilock braking systems reduced crash risk by 65%. All of these results were statistically significant at the 95% confidence level. Other safety technologies also showed estimated benefits, although not statistically significant. *Conclusions*: With the exception of the finding that short-haul exemption is associated with increased crash risk, results largely bolster what is currently known about large truck crash risk and reinforce current enforcement practices. Results also suggest vehicle safety technologies can be important in lowering crash risk. This means that as safety technology continues to penetrate the fleet, whether from voluntary usage or government mandates, reductions in large truck crashes may be achieved. *Practical application*: Results imply that increased enforcement and use of crash avoidance technologies can improve the large truck crash problem.

1. Introduction

Large trucks serve a vital function in the U.S. economy. Their large size and weight, while advantageous in transporting freight efficiently, are a disadvantage in terms of highway safety. In 2014, the latest year for which data are available, large trucks were involved in an estimated 410,605 police-reported crashes (estimated from the National Automotive Sampling System — General Estimates System national sample of police reported crashes) that resulted in 3660 deaths (Insurance Institute for Highway Safety (IIHS), 2016). Large truck crashes tend to be severe. Large trucks often are 20–30 times heavier than the average passenger car, and their increased height and ground clearance increases the risk that a smaller vehicle will underride the trailer during a crash (Brumbelow, 2012; Brumbelow & Blanar, 2010). In 2014, 68% of deaths in large truck crashes were passenger vehicle occupants (IIHS, 2016). Another 15% were motorcyclists, pedestrians, or bicyclists, and 16% were the occupants of large trucks.

Large truck safety is regulated at the state and federal level. The National Highway Traffic Safety Administration (NHTSA) sets standards for new truck equipment and has some jurisdiction over equipment standards for trucks currently on the road. The Federal Motor Carrier Safety Administration (FMCSA) regulates the use of large trucks in interstate commerce (operating across state lines). FMCSA regulations cover carrier operations, truck equipment, vehicle inspection and maintenance, and hours-of-service and various other aspects of driver safety such as testing and licensing, medical requirements, and drug and alcohol testing.

Vehicles with gross vehicle weight ratings (GVWR) exceeding 10,000 lb are considered large trucks. Federal rules currently limit trucks on interstate highways to 80,000 lb, although some states allow heavier trucks on some roads within their borders. Federal regulations require a commercial driver license (CDL) to operate a vehicle with a GVWR exceeding 26,000 lb; knowledge and skills testing standards for a CDL are set by FMCSA but administered by state driver licensing agencies. If large trucks cross state lines or carry hazardous materials, their drivers must be 21 or older. States can permit drivers ages 18–20 to operate large trucks within the state.

Enforcement of federal regulations is shared by FMCSA and the states. The responsibility for regulating and enforcing the safety of intrastate commercial vehicle travel resides with the states. Large trucks are subject to on-the-spot inspections by law enforcement personnel. Carriers' compliance with regulations and their safety records also are reviewed through an FMCSA program called Compliance, Safety, and

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Accountability (CSA) in which carriers with high violation and crash rates are subject to interventions ranging from warning letters to service suspension.

One set of federal regulations governs the work and rest schedules of interstate drivers. Under current regulations, interstate truck drivers cannot drive for more than 11 h or drive after 14 h since starting a duty shift until they take a 10-h break. Additionally, drivers are required to spend at least 30 min off-duty after no more than 8 h of driving. Drivers cannot drive after accruing 60 work hours during a 7-day period or 70 work hours during an 8-day period, but a "restart" provision allows truckers to get back behind the wheel after 34 h off-duty. Regulations currently allow truck drivers to record their hours in written logbooks that are reviewed by inspectors. As of December 2017, electronic logging devices will be required for all carriers that are required to use logbooks.

With regard to important vehicle standards, antilock braking systems (ABS) have been required on new tractors since March 1997 and on new trailers and single-unit trucks since March 1998. In July 2009, NHTSA issued a final rule that decreased by 30% the maximum stopping distances for air-braked trucks. The rule went into effect on August 1, 2011, for three-axle tractors with GVWRs of 59,600 lb or less. Two-axle tractors and tractors with GVWRs more than 59,600 lb had to comply with the reduced stopping distance requirements by August 1, 2013. Large trucks' high centers of gravity increase their risk of rolling over, particularly on curved roadway segments such as ramps. Vehicle stability control systems are designed to intervene when a truck's motion becomes unstable, possibly resulting in rollover, jackknife, or other loss of control. Electronic stability control (ESC) will be required on all new typical three-axle tractors manufactured on or after August 1, 2017. The remaining types of truck tractors have until 2019 to comply. Other crash prevention technologies are available on large trucks but are not yet required. These technologies include forward collision warning (with and without autobrake), lane departure warning, and blind spot warning.

NHTSA also imposes rear-impact guard standards for large trucks, although several types of trucks are exempt from the current rule including single-unit trucks, trucks with rear wheels set very close to the back of the trailer, and various types of special-purpose trucks. NHTSA issued a proposed upgrade to the rear underride regulations for tractor–trailers in December 2015 and also has proposed that the regulations be extended to new single-unit trucks.

While crash mitigation strategies are important, the best remedy for large truck crashes is prevention. A key step in developing effective strategies for preventing large truck crashes is understanding what factors are associated with increased crash risk. There have been many studies describing truck crashes, but few have examined the factors associated with increased truck crash risk using strong research designs. Controlling for exposure is one of the most important considerations in studying risk factors. For example, if one observes a factor in, say, 12% of crash-involved trucks, this would not be considered a risk factor if 12% of all trucks on the road also have that factor. The Large Truck Crash Causation Study (LTCCS) collected highly detailed information on a sample of large trucks involved in crashes (FMCSA, 2006). However, no control data were collected, so researchers studied crash risk indirectly by measuring the relative likelihood that the truck was the vehicle with the last action that made the crash unavoidable (termed the "critical event" and not necessarily the chief contributory factor in the crash). For instance, Blower, Green, and Matteson (2010) found that a truck with out-of-adjustment brake violations was 1.8 times as likely to be the vehicle with the critical event, compared with a truck without such violations, but could not estimate the relative overall crash risk associated with such violations.

A common finding of research involving LTCCS, as well as other data sources, is that many or most multiple-vehicle truck crashes result from driving mistakes or misbehavior on the part of light vehicle drivers (Blower, 1998; Council, Harkey, Khattak, & Mohamedshah, 2003; FMCSA, 2006; Hanowski, Wierwille, Garness, & Dingus, 2000; Kostyniuk, Streff, & Zakrajsek, 2002). Human error largely is inevitable, so addressing it typically is a matter of laws and regulations targeting risk factors rather than the behaviors themselves. For example, driver fatigue is a well-known, and difficult to measure, problem in truck crashes (Knipling & Shelton, 1999; McCartt, Rohrbaugh, Hammer, & Fuller, 2000; National Transportation Safety Board, 1990). Thus, the hours-of-service rules seek to reduce fatigue by restricting the number of driving and work hours to ensure drivers have adequate off-duty periods to obtain restorative rest.

A pair of papers published in the 1980s took the most direct approach to identify large truck crash risk factors. Stein and Jones (1998) Q5 conducted a matched case–control study of trucks involved in crashes of any severity in Washington state. For each crash-involved truck, three control trucks were selected on the basis of location, time of day, and day of week and inspected by police specializing in commercial vehicles. This study design removes any possible confounding effects from these factors and provides a strong measure of exposure. The authors found that trucks with more than one trailer were overrepresented in crashes. They also found that empty trucks, drivers 30 and younger, and interstate carriers were at increased crash risk. Using the same study data, Jones and Stein (1989) investigated the role of defective equipment in large truck crash risk. They found that trucks with defects identified during vehicle inspections, particularly brake and steering violations, were associated with increased crash risk. They also found that driving more than 8 h, drivers 30 and younger, and interstate carriers were associated with increased crash risk.

Using a similar approach, the current study provides an updated examination of the risk factors for large truck involvements in crashes resulting in injury or death.

2. Methods

A matched case–control design was used, focusing on large trucks operated in North Carolina by interstate carriers. Cases were defined as trucks involved in serious crashes, and controls were trucks not involved in crashes matched by location, time, and truck type. This allowed comparing the relative prevalence of various factors to determine which are associated with increased crash risk.

The Insurance Institute for Highway Safety partnered with the University of North Carolina (UNC) Highway Safety Research Center and the North Carolina State Highway Patrol Motor Carrier Enforcement division (hereinafter referred to as the Highway Patrol). UNC developed the data collection methods, coordinated data collection with the Highway Patrol, and maintained all data files. The study protocol was approved by the UNC Institutional Review Board.

The Highway Patrol monitors roadways and responds to crashes in non-municipal areas of North Carolina. Six of the agency's eight regions participated in the current study; two regions were not included because they have relatively little large truck traffic. For large truck crashes involving apparent serious injuries or deaths, it is standard practice for officers to perform a full investigation of the truck and driver conforming to the Commercial Vehicle Safety Alliance (CVSA, 2016a) Level I inspection criteria. CVSA Level I inspections include examination of the driver's logbook, CDL, medical certificate, and other driver requirements, as well as all major vehicle systems such as brakes, tires, lights, and suspension. Inspections are performed by CVSA-certified troopers in the Motor Carrier Enforcement division. The troopers who participated in the current study conducted inspections of the control trucks on an overtime basis and were compensated with project funds.

Cases were defined as large trucks involved in serious crashes. Specifically, the following inclusion criteria were employed:

- Truck operated by interstate carrier
- Truck had GVWR exceeding 26,000 lb and three or more axles

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