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Examining the Relationship Between CMV Driver Retention and Safety

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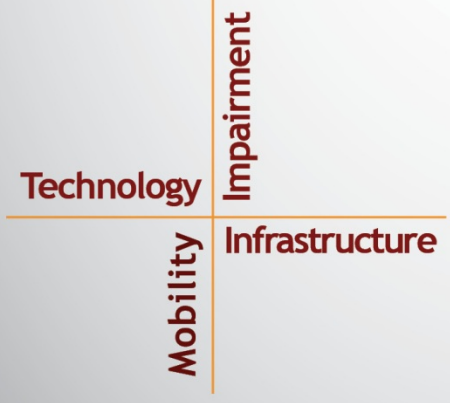

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EXECUTIVE SUMMARY

Many segments in the trucking industry experience extremely high rates of driver turnover. For example, the truckload segment experiences turnover rates between 85% and 90% (Costello & Karickhoff, 2019). Although some research has shown a link between high driver turnover and increased crash risk, it is not known if voluntary turnover affects crash risk. The purpose of this study was to examine the relationship between voluntary and involuntary driver turnover with involvement in Federal Motor Carrier Safety Administration (FMCSA)-reportable crashes and moving violations.

METHODS

This study used data collected in the recently completed Commercial Driver Safety Risk Factors (CDSRF) study (Hickman et al., 2020). The CDSRF study examined individual driver risk factors using a sample of 21,000 drivers from a single, large, for-hire carrier. Data included driver medical, demographic, crash, and other qualitative data collected over 3 years through surveys and medical examination reports. Included in the CDSRF study were drivers' date(s) of hire and termination (if appropriate), body mass index (BMI), and age. Additionally, the CDSRF study included carrier-provided crash records, FMCSA-reportable crash records, and FMCSA violation records.

Determining Employment Status

Researchers identified all drivers' unique employment periods using the hire dates and employment end dates provided by the carrier. All employment end dates were compared to carrier and FMCSA records. Researchers calculated the time between the crash occurrence and the most recent employment end date. Drivers' employment was considered ceased after a crash if a crash occurred in the 7 days preceding the employment end date. Drivers' employment was considered ceased without a crash if they did not have a crash in the 7 days preceding the employment end date. This resulted in four groups of drivers:

1. **Continuously employed drivers:** Drivers with a single unique hire date and no employment end date.

2. **Drivers with multiple employment periods:** Drivers with an employment end date listed and an additional, more recent rehire date that did not result in ceased employment.

3. **Drivers with ceased employment following a recent crash:** Drivers with an employment end date within 7 days of a crash.

4. **Drivers with ceased employment without a recent crash:** Drivers with an employment end date but without a crash within the previous 7 days.

Exposure

For drivers who left the carrier, exposure was calculated by taking the most recent employment end date available and calculating the number of days from the ceased employment date until May 30, 2016 (i.e., the end of the study). For drivers who stayed with the carrier, exposure was

calculated as days since the most recent hire date until May 30, 2016. Exposure in days was used to calculate the rate of national crashes and moving violations for each driver in the study.

Analyses

Poisson regression models were used to measure the relationship between safety outcome rate and the employment status of the drivers. For each driver, the number of safety outcomes in the exposure window was modeled as a response variable, with employment status as a predictor variable. The models were adjusted for age and BMI. Exposure in days was used as an offset variable. Chi-square tests of independence were used to measure the association between demographic variables and employment status group (i.e., do employment status groups have significant differences in their distribution of demographic variable levels?).

RESULTS

The final data set included 12,038 total drivers. Table ES-1 lists the driver count and percentage of total drivers by termination status.

Table ES-1. Distribution of drivers by employment status.

Employment Status	Driver Count	Percentage of Total
Continuous employment	2,971	24.68%
Multiple employment periods	73	0.61%
Ceased employment after crash	143	1.19%
Ceased employment without crash	8,851	73.53%

Table ES-2 shows the overall results comparing the crash and violation risk of drivers across all employment status groups. Statistically significant results are indicated with an "*." Overall, drivers who had continuous employment were significantly less likely to be involved in a future FMCSA-reportable crash or receive a violation compared to drivers that left the carrier at any time. Furthermore, drivers that left the carrier without a recent crash were significantly less likely to be involved in an FMCSA-reportable injury crash compared to drivers that left the carrier following a recent crash.

Table ES-2. Risk ratios and confidence intervals comparing each employment status group.

Comparison Group 1	Comparison Group 2	FMCSA-reportable Overall Crash Rate	FMCSA-reportable Injury Crash Rate	Moving Violation Rate
Continuous Employment	Drivers with Crash	**0.2502* (0.1323, 0.4731)**	**0.1394* (0.0600, 0.3238)**	**0.4878* (0.2878, 0.8268)**
Continuous Employment	Drivers without Crash	**0.3547* (0.2755, 0.4567)**	**0.3444* (0.2252, 0.5266)**	**0.5626* (0.4779, 0.6623)**
Drivers without Crash	Drivers with Crash	0.7053 (0.3881, 1.2817)	**0.4048* (0.1903, 0.8611)**	0.8670 (0.5203, 1.4448)
Continuous Employment	Multiple Employment	**0.2535* (0.1100, 0.5842)**	0.2638 (0.0623, 1.1163)	**0.3824* (0.2021, 0.7234)**
Drivers without Crash	Multiple Employment	0.7146 (0.3195, 1.5984)	0.7659 (0.1901, 3.0855)	0.6797 (0.3643, 1.2680)
Drivers with Crash	Multiple Employment	0.9869 (0.3648, 2.6699)	0.5286 (0.1097, 2.5464)	1.2757 (0.5729, 2.8406)

DISCUSSION

Previous research has found that driver turnover is associated with higher crash rates (Corsi & Fanara, 1988; Staplin & Gish, 2005); however, it remains unclear if drivers who voluntary change jobs have higher crash rates compared to drivers who stay in the same job or are fired due to crash involvement or safety violations. Results from this study confirm that driver retention is significantly related to safety. Furthermore, this study found that voluntary and involuntary turnover is associated with higher crash and moving violation risk compared to drivers who remain with a carrier.

Specifically, this study found that crash and violation risk was lowest for drivers that stayed with the carrier over the 3-year study, rose for drivers that left the carrier without a recent crash, and was highest for drivers that left the carrier following a crash in the previous 7 days. Furthermore, there were few significant differences between drivers that left the carrier without a recent crash, drivers with ceased employment following a crash, and drivers with multiple employment periods at the same carrier during the 3 years of data collection.

These results support the need for carriers to adopt programs and policies designed to encourage safe drivers to remain at the same carrier. The programs and policies should include comprehensive compensation packages with competitive pay and benefits, desirable routes and schedules, and well-maintained trucks (Suzuki et al., 2009; Williams et al., 2011). Additionally, carriers should encourage dispatchers to develop positive relationships with drivers as dispatchers have the most frequent communication with drivers (Keller, 2002; Keller & Ozment, 1999a, b). Finally, carriers should have open communication with drivers to make sure their needs are met (Suzuki et al., 2009). By creating driver-focused programs and policies, safe and experienced drivers should be more likely to remain at the same carrier and thus help the carrier realize lower crash rates.

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LIST OF ABBREVIATIONS AND SYMBOLS

ATA	American Trucking Associations
ATRI	American Transportation Research Institute
BMI	body mass index
CDLIS	Commercial Driver's License Information System
CDSRF	Commercial Driver Safety Risk Factors
CI	confidence interval
CMV	commercial motor vehicle
FMCSA	Federal Motor Carrier Safety Administration
ID	identification
MCMIS	Motor Carrier Management Information System
RR	risk ratio

CHAPTER 1. INTRODUCTION

As the trucking industry continues to grow, there is an increased need for safe commercial motor vehicle (CMV) drivers. Unfortunately, many CMV carriers are concerned that there are not enough current drivers or new individuals entering the industry to meet demand. Each year, the American Transportation Research Institute asks CMV industry stakeholders to rate their top concerns, and most recently these stakeholders rated driver shortage and driver retention as the number one and number six concerns, respectively (American Transportation Research Institute, 2019). Current projections from the American Trucking Associations indicate that the trucking industry will have a shortage of between 60,800 and 160,000 drivers by 2028 (Costello & Karickhoff, 2019). High turnover of drivers is also a problem. For example, truckload carriers experience driver turnover rates between 85% and 90% (Costello & Karickhoff, 2019). This high turnover makes it more difficult for CMV carriers to maintain enough drivers to operate their trucks.

Contributing to the current and projected driver shortage is that CMV drivers tend to be older and less healthy. The median age of CMV drivers (49 years old) is 7 years older than the median age of the entire U.S. labor force (42 years old), and the median age of CMV drivers is even older in certain industry segments (Costello & Suarez, 2015). Another factor that may contribute to an older CMV driving workforce is the current minimum age requirement for interstate commerce. Currently, CMV drivers must be at least 21 years old to operate a CMV across state lines. Since interstate CMV carriers cannot hire individuals between 18 and 21, some individuals who may be interested in driving a CMV might select an alternative career path, meaning that fewer young people may be entering the CMV job market to replace the drivers aging out.

Howarth et al. (2007) conducted a literature review of non-regulatory factors that may be associated with CMV safety. They found a possible indirect association between decreased safety performance and high driver turnover, the selection of unqualified drivers, inexperienced drivers, and compensation. Additionally, Staplin et al. (2003) identified an association between crash risk and driver turnover. Using the Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System (MCMIS), they found that crash risk began to increase when drivers were employed by two carriers in a year for two consecutive years.

However, understanding the relationship between CMV driver retention and safety is more complex than simply looking at how many carriers a driver has worked for in a given amount of time. Some drivers may change jobs because they were terminated due to crash involvement, but other drivers may change jobs for a host of other reasons. It is unclear if crash risk differs for forced turnover (employment terminated due to crash involvement) and voluntary turnover (driver changes employers for personal reasons). Additional data and information are needed to better understand the relationship between driver retention and CMV safety. Data collected in the recently completed Commercial Driver Safety Risk Factors (CDSRF) study provides a unique opportunity to expand on Staplin et al. (2003) and gain insight into these relationships.

OBJECTIVE

The purpose of this study was to examine the relationship between voluntary and involuntary driver turnover with involvement in future FMCSA-reportable crashes and moving violations.

Specifically, the study used the questionnaire and crash data collected in the CDSRF study to compare the crash risks of drivers that maintained employment, drivers that voluntarily changed jobs, and drivers that were terminated or who resigned after a crash.

CHAPTER 2. UNDERSTANDING CMV DRIVER RETENTION

Researchers searched the relevant published literature on CMV driver retention and safety using multiple Internet sites and searchable literature databases containing peer-reviewed and trade publications, government reports, and conference proceedings. This chapter summarizes the results of this literature search.

DRIVER RETENTION AND SAFETY RESEARCH

Each year the trucking industry incurs substantial recruiting, training, and other costs—such as loss of revenue—as a result of drivers unexpectedly leaving their jobs. Another potential cost of CMV driver turnover is decreased roadway safety. Although there has been considerable research on the factors that affect driver turnover, few studies investigate how driver retention affects safety. Two different approaches were identified in the research literature for examining the impacts of job turnover and safety or crash risk among CMV drivers: (1) an analysis of aggregate data involving motor carriers, and (2) an analysis of individual data involving truck drivers.

Corsi and Fanara (1988) analyzed safety audit data from approximately 860 CMV carriers to examine to the relationship between carrier crash rates and several operational and management factors, including driver turnover. A multiple regression analysis showed that high driver turnover and other management-related practices were associated with higher crash rates. Results from this study highlight the importance of comprehensive driver-focused programs to mitigate reasons why drivers may leave. Adopting such policies and practices could help carriers lower their crash rates and driver-replacement costs.

The data used in Corsi and Fanara's study was from the late 1980s, when the average driver turnover rate was about 38%. However, turnover rates in some industry segments have risen significantly since 1995. Specifically, large and small truckload carriers have turnover rates of 94% and 79%, respectively (Burks & Monaco, 2019). Although the less-than-truckload segment experiences significantly less turnover (approximately 11%), it is still significantly higher than the average turnover rate across the United States (Burks & Monaco, 2019). With driver turnover significantly higher now, the safety-related impacts may be even be even greater today than in the late 1980s.

Staplin and Gish (2005) used aggregated data to assess the effect of driver turnover on safety. Using FMCSA's MCMIS database, they found that CMV drivers who changed employers multiple times each year for multiple years were involved in more crashes compared to drivers that did not change employers as frequently. Specifically, CMV drivers who worked for three or more carriers within a year were twice as likely to be involved in multiple crashes compared to drivers that stayed with the same employer (Staplin & Gish, 2005). Similarly, af Wåhlberg and Dorn (2018) found that bus drivers who changed employers were involved in 40% more crashes than bus drivers that did not change employers. However, the drivers that changed jobs were less experienced, which may account for some of the difference in the crash numbers.

However, not all turnover is bad. Carriers often dismiss drivers who do not follow company procedures, do not operate their vehicles safely, have failed a random drug test, or have been

involved in an at-fault crash. There is sparse research examining the safety implications associated with voluntary versus involuntary turnover. Only two studies examined factors influencing differences between involuntary and voluntary turnover rates (Gupta, Jenkins, & Delery, 1996; Shaw et al., 1998). These studies found that the rate of voluntary turnover was 4 times higher than the rate of involuntary turnover. Further, the carriers with the lowest voluntary turnover rates offered drivers more home time, were more selective in their hiring, and offered higher pay and better benefits. However, neither study examined the safety implications of involuntary versus voluntary turnover.

DRIVER COMPENSATION AND TURNOVER

Many factors may influence a driver's decision to voluntarily leave a carrier. Compensation is generally one of the major deciding factors leading to an employee leaving, regardless of the industry in question. This is no different in the motor carrier industry. The issue of driver compensation is complex and goes beyond pay per mile. Driver compensation also includes scheduling and how many miles a driver can drive from week to week, as well as which customers are delivered to and the amount of waiting, loading, and unloading time. Additionally, compensation includes the equipment; older equipment that breaks down regularly affects the number of miles a driver can drive. Pay is a combination of all these factors and not many researchers factor all of them into the driver's compensation package. Several studies have shown that driver compensation is a primary reason for voluntary turnover in the CMV industry (Stephenson & Fox, 1996; Dobie et al., 1998; Keller & Ozment, 1999a; Min & Lambert, 2002; Keller, 2002; Suzuki et al., 2009). These results suggest that higher driver pay is strongly related to reduced driver turnover.

McKenzie et al. (2018) collected survey data from CMV drivers and modeled factors related to voluntary turnover. One of the more important factors was how satisfied the driver was with their pay. Faulkiner (2016) found that large wage increases significantly improved carriers' ability to attract and retain safe drivers while reducing crash rates and crash costs. Although pay increases for experienced, safe CMV drivers raise costs, these costs are significantly outweighed by improved driver retention and reduced crash costs compared to hiring less-experienced, unsafe drivers. In turn, carriers that spent more money to hire experienced, safe drivers had a significantly higher return-on-investment compared to carriers that did not (Faulkiner, 2016).

RELATIONSHIP WITH DISPATCHERS AND DRIVER TURNOVER

Although pay is an important factor contributing to driver turnover, other factors pertaining to organizational policies, people, and safety culture also influence a driver's decision to leave a carrier. Dispatchers are the direct link to drivers and are able to determine driver concerns before they escalate to a critical stage—before the driver starts to think about leaving the motor carrier. Therefore, the relationship between the driver and dispatcher is critically important for reducing driver turnover. This makes the education of dispatchers an important tool for improving driver retention. Treating drivers with respect and courtesy helps to diffuse tensions and reduce turnover (Keller & Ozment, 1999b).

Keller and Ozment (1999a) found that carrier dispatchers have a large influence on driver retention. Higher rates of driver retention were found in carriers with dispatchers who actively

listen to driver concerns, take action to address concerns, and treat drivers with respect compared to dispatchers with poor communication skills and lack of empathy. They also found that dispatchers must have proper working conditions and tools for managing communication with drivers. It was not uncommon in Keller and Ozment's study for dispatchers to be responsible for scheduling 50 or more drivers. Dispatchers need proper communication tools to manage this many drivers.

Similarly, Keller (2002) surveyed motor carrier dispatchers and found that driver retention is highly correlated to how responsive dispatchers are to driver concerns. Drivers who worked for responsive dispatchers were more likely to be responsive to customers. Further, these drivers performed better and were more likely to stay with the carrier (Keller, 2002).

JOB SATISFACTION AND DRIVER TURNOVER

Kalnbach and Lantz (1997) found that job satisfaction was linked to turnover. Drivers with higher levels of job satisfaction had longer tenures with their fleet and were less likely to voluntarily leave their job. The Gallup organization (1997) surveyed CMV drivers who remained at the same fleets for 5 or more years and found that many factors associated with job satisfaction were predictors of driver retention. Additionally, the survey found that reliable work schedules, management support, higher pay, fleet responsiveness to needs, and acceptable work hours were the top predictors to CMV driver job satisfaction (Gallup, 1997). Similarly, Stephenson and Fox (1996) found that higher perceptions of job satisfaction were associated with more favorable views of carrier management and dispatchers. They also found that drivers who did not view their current carrier as significantly better than others were more likely to voluntarily leave their job (Stephenson & Fox, 1996). Taylor and Whicker (2010) found that improved regional dispatching procedures reduced the need for extended routes requiring many days away from home, thus improving driver perceptions of job satisfaction.

Suzuki et al. (2009) modeled driver turnover with two motor carriers and found that driver turnover is predicted by operational factors. Assigned miles or routes, weekends away from home, and pay were found to be the best predictors of voluntary turnover. Furthermore, Suzuki et al. (2009) found that voluntary turnover is most affected by recent negative experiences (i.e., low assigned mileage, undesirable work schedule, etc.) within the previous 3 weeks.

OTHER ORGANIZATIONAL FACTORS AND DRIVER TURNOVER

Many other factors related to organizational culture influence driver retention. Several studies found that driver retention was associated with organizational commitment, perception of fairness in policies and procedures, day-to-day support that demonstrates caring and appreciation of drivers, active concern for driver safety and security, well-maintained equipment, good working conditions, driver employment benefits, and carrier reputation within the industry (Dobie et al., 1998; Min & Lambert, 2002; Stephenson & Fox, 1996). Drivers with negative perceptions of any of these factors were more likely to leave their employer compared to drivers who had positive perceptions of these factors.

Williams et al. (2011) used social exchange and organizational support theories to better understand why drivers remain with or leave a motor carrier. Based on these theories, drivers

continuously assess the value of their contributions to a job versus the benefits they receive from that job. Drivers stay with one employer when they perceive that the benefits equal their contribution; however, voluntary turnover occurs when drivers perceive that the benefits are less than their contribution. According to Williams et al. (2011), the following variables predict driver turnover, in order of importance:

1. Driver pay
2. Personal safety
3. Time at home
4. Well-maintained equipment
5. Career advancement
6. Workload
7. Dispatcher
8. Career development
9. Company reputation
10. Relationship with customers
11. Relationships with other drivers
12. Company recognition and rewards
13. Cargo
14. Loading and unloading requirements
15. Realistic recruiting tactics
16. Top management
17. Company orientation program

As shown above, driver compensation, perceptions of safety, the amount of home time, and good equipment were found to be the most important variables that affect driver retention. A cluster analysis showed that these factors could be grouped into three primary categories: (1) primary needs, (2) organizational relationships, and (3) career advancement. Furthermore, the importance of each of these categories varied according to driver age and experience (Williams, et al., 2011).

CHAPTER 3. METHODS

This study used data collected in the CDSRF study (Hickman et al., under Agency review). Over 21,000 drivers were recruited for the CDSRF study from a single, large, for-hire carrier during driver orientation. There were eight recruitment sites located across the United States. Participating drivers were compensated. Over a 3-year period, the study collected driver medical, demographic, safety, and other qualitative data through surveys and medical examination reports. This study used these data to create a database that included the date(s) of hire and termination (if appropriate), body mass index (BMI), and age. The final data set for this study included all drivers for whom all three variables were available. The study also collected safety outcome data for participating drivers. Safety outcome data included carrier-provided crash records, national crash records, and nationally recorded violation records.

DETERMINING EMPLOYMENT STATUS

Carrier-provided data included driver hire and employment end dates, which were updated over the course of data collection. All license numbers received a randomly assigned driver ID. The carrier-provided data were sorted by driver ID and all unique employment periods were identified using the included hire and employment end dates. Driver IDs with no hire or employment end date were removed from the analysis. Drivers with a single unique hire date and no employment end date were labeled as having continuous employment. Drivers with an employment end date listed and an additional, more recent rehire date that did not have an end date were labeled as having multiple employment periods. Drivers with a single hire and employment end date were considered drivers with ceased employment. Drivers with multiple employment periods with the most-recent date listed as an employment end date were also considered ceased employment.

Drivers with ceased employment were then compared to crash data sets to determine if the ceased employment date followed a recent crash. The array of driver IDs and their most-recent employment end date was matched to the MCMIS crash and carrier-recorded crash data sets. The time between the crash occurrence and the most-recent employment end date was calculated. Drivers with ceased employment after a crash were considered those whose employment ended within 7 days of a crash. Drivers with ceased employment without a crash were considered those whose employment ended without a crash in the 7 days preceding the employment end date. The data did not include any additional information regarding who made the employment decision (driver or carrier) and any motive behind the decision.

The data set included four employment statuses: continuously employed drivers, drivers with multiple employment periods, drivers with ceased employment following a crash, and drivers with ceased employment without a crash in the preceding 7 days. Drivers in all four employment status groups could potentially have crashes during their tenure with the carrier. The distinction in this study is how close a crash occurred to the employment end date or whether a driver ceased employment at all.

SAFETY OUTCOME DATA SETS

Two safety outcomes were included in this analysis: national crashes from the FMCSA's MCMIS database and violations from the Commercial Driver's License Information System (CDLIS) database. The carrier-provided carrier crash data set was not used as a safety outcome measure since these data did not contain crashes for drivers with ceased employment. However, the carrier-provided crash data set was used to identify preventable and non-preventable crashes prior to a driver leaving the carrier.

MCMIS Crash Data

MCMIS is FMCSA's main database to track the safety performance of CMV carriers and hazardous material shippers. It includes vehicle, driver, and event data on every FMCSA-reportable crash, violation, or inspection involving a CMV. FMCSA-reportable crashes include all CMV crashes involving a fatality, injury requiring transportation via emergency services, or a vehicle towed away from the scene. This data set allowed researchers to track safety performance after termination.

As all crashes in MCMIS are linked to a driver's license, the MCMIS data set was used to identify crashes that occurred while a driver was employed at the participating carrier and after ending employment at the carrier. Crashes in MCMIS include details such as crash date, crash description, number of injuries, and number of fatalities. Drivers with ceased employment and drivers with continuous or multiple employment periods were matched to the MCMIS crash data using two different date windows. For drivers with ceased employment, the first date window included the time from hire until employment ended and was used to calculate the number of days between the most recent crash and termination. The second date window for these drivers included the time from ending employment until the end of the study and was used to calculate the crash rate after leaving the carrier. The crashes were summarized by the total number of all crashes, injury crashes, and fatal crashes per driver in the second date window. For drivers with continuous employment and drivers with multiple employment periods, the date window included the most recent or only hire date until the end of the study. For these drivers, the per-driver total number of all crashes, injury crashes, and fatal crashes in the time window were calculated to determine the crash rate during employment.

CDLIS Violation Data

CDLIS is a single database that contains all violations, convictions, and complete records for all CMV driver licenses. The CDLIS violation data set was used as an additional safety outcome measure in the comparison of employment status groups. The violation data set used in this study included moving violation convictions filtered in the CDSRF to ensure that all moving violation convictions associated with a crash were removed. A list of moving violation types used in this study is included in the appendix.

Following the method used for the crash data set, violations were matched to drivers with ceased employment and drivers with continuous or multiple employment periods using the same date windows specified above. A count of total violations in the date window was calculated for each driver.

EXPOSURE CALCULATION

Exposure was calculated for each driver using the date windows described previously. For drivers with ceased employment, exposure was calculated by taking the most recent employment end date available and calculating the number of days from the end date until May 30, 2016 (i.e., end of the study). For drivers with continuous employment or multiple employment periods, exposure was calculated as days since the most recent hire date until May 30, 2016. Exposure in days was used to calculate the rate of national crashes and moving violations for each driver in the study.

ANALYSIS METHODS FOR DEMOGRAPHIC VARIABLE LEVELS

The demographic variables age, BMI, and gender were used to characterize the four employment status groups. Calculations of the average and range of age and BMI as continuous variables are presented in the report. To continue the methods established in the CDSRF study, age and BMI were also compared in interval categories. The proportion of drivers in each employment status was found for the age quartiles 21–33 years, 34–42 years, 43–51 years, and 52 years and older. Six BMI intervals were defined: less than 18.5, 18.5 to 24.9, 25.0 to 29.9, 30.0 to 34.9, 35.0 to 39.9, and 40.0 and above. Levels for gender in the analysis data set included male and female.

A chi-square test of independence was used to measure the association between demographic variables and employment status group (i.e., do employment status groups have significant differences in their distribution of demographic variable levels?). An example contingency table in Table 1 shows age quartiles by employment status groups. The chi-square test of independence compares the contingency table observed values, driver counts occurring in each row i by column j cell (o_{ij}), to the expected value (e_{ij}), calculated using the formula below in Figure 1. In the test statistic formula, r is the number of rows and c is the number of columns. The calculated test statistic is compared to the chi-square critical value (degrees of freedom equal to $r - 1 * c - 1$).

Table 1. Contingency table example for chi-square test of independence.

Age Quartile	Continuous Employment	Multiple Employment Periods	Ceased Employment After Crash	Ceased Employment Without Crash
21–33 years	o_{11}	o_{12}	o_{13}	o_{14}
34–42 years	o_{21}	o_{22}	o_{23}	o_{24}
43–51 years	o_{31}	o_{32}	o_{33}	o_{34}
52 years and older	o_{41}	o_{42}	o_{43}	o_{44}

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{\left(o_{ij} - e_{ij}\right)^2}{e_{ij}} \; where \; e_{ij} = \frac{row\ i\ total * column\ j\ total}{total\ number\ of\ drivers}$$

Figure 1. Equation. Formula for calculating the chi-square test of independence test statistic.

POISSON REGRESSION MODELS FOR SAFETY OUTCOME RATE

Poisson regression models were used to measure the relationship between safety outcome rate and the employment status of the drivers. For each driver, the number of safety outcomes in the exposure window was modeled as a response variable, with employment status as a predictor variable. The models were adjusted for age and BMI. Exposure in days was used as an offset variable. A log link function was used to link the safety outcome rate to the model explanatory variables of employment status, age, and BMI, using the formula shown in Figure 2:

$$\log(\lambda_i) = \beta_0 + \beta_{empl.\ status} X_i^{empl.\ status} + \beta_{age} X_i^{age} + \beta_{BMI} X_i^{BMI}$$

Figure 2. Equation. Formula of log link function used to link the safety outcome rate to the model explanatory variables of employment status, age, and BMI.

where $X_i^{empl.\ status}$ is the employment status for driver i; X_i^{age} and X_i^{BMI} are the age and BMI for driver i, respectively; and βs are the regression coefficients. To maintain the methods used for CDSRF, each safety outcome was modeled within an age quartile. These quartiles were defined as 21–33 years, 34–42 years, 43–51 years, and 52 years and older.

CHAPTER 4. RESULTS

DRIVER DEMOGRAPHIC CHARACTERISTICS BY DRIVER EMPLOYMENT STATUS

The counts of drivers by employment status and the corresponding distributions of age, BMI, and gender by employment status are presented here. Drivers had to have data for age and BMI, as well as a hire date, to be included in the analysis. The final data set included 12,038 drivers. Table 2 lists the driver count and percentage of total drivers by employment status. Just under three-quarters (73.53%) of the drivers in the study ceased employment without a crash in the prior week. Nearly 25% of the drivers were continuously employed. Few drivers (143 drivers, 1.19% of total) ceased employment within 1 week of a crash. Drivers with multiple employment periods made up the smallest group included in the analysis (73 drivers, 0.61%).

Table 2. Distribution of drivers by employment status.

Employment Status	Driver Count	Percentage of Total
Continuous employment	2,971	24.68%
Multiple employment periods	73	0.61%
Ceased employment after crash	143	1.19%
Ceased employment without crash	8,851	73.53%

The average age by employment status is listed in Table 3. Continuously employed drivers had an average age of 42.70 years with an age range from 21 to 78 years. Drivers with multiple employment periods had an average age of 43.44 years with an age range of 23 to 70 years. Drivers with ceased employment after a crash had an average age of 40.82 with an age range of 21 to 73 years. Drivers with ceased employment without a crash in the previous week had an average age of 42.25 with an age range of 21 to 79 years.

Table 3. Distribution of reported age by employment status.

Employment Status	Driver Count	Average Age	Standard Deviation	Minimum Age	Maximum Age
Continuous employment	2,971	42.70	11.07	21.00	78.00
Multiple employment periods	73	43.44	12.46	23.00	70.00
Ceased employment after crash	143	40.82	13.46	21.00	73.00
Ceased employment without crash	8,851	42.25	11.07	21.00	79.00

Table 4 shows the number and percentage of drivers in each age quartile by employment status. Drivers with ceased employment within 7 days of a crash had a slightly higher proportion of drivers aged 21 to 33 years (36.36%), compared to continuously employed drivers (24.01%), drivers with multiple employment periods (24.66%), and drivers with ceased employment without a crash in the preceding 7 days (25.03%). For the age quartile 44 to 51 years old, drivers with ceased employment within 7 days of a crash had a lower proportion of drivers (18.88%) than the three other employment status groups (26.61% of continuously employed driver group, 17.81% of drivers with multiple employment periods, and 26.98% of drivers with ceased employment without a crash in the preceding 7 days). A chi-square test assessing the

employment status distributions of driver proportions across the age quartiles indicated significant differences (X^2 = 22.68, p = 0.0070). Post hoc tests identified significant differences in the age distributions for drivers with ceased employment with a recent crash and the status groups of drivers with ceased employment without a crash in the preceding 7 days (X^2 = 12.47, p = 0.0059) and continuously employed drivers (X^2 = 12.88, p = 0.0049). Continuously employed drivers had approximately equal proportions among all four age quartiles. This pattern was also observed in drivers with ceased employment without a crash in the preceding 7 days. The proportions are also plotted in Figure 3.

Table 4. Distribution of driver frequency by age quartile.

Age Quartile	Continuous Employment	Multiple Employment Periods	Ceased Employment After Crash	Ceased Employment Without Crash
21–33	713 (24.00%)	18 (24.66%)	52 (36.36%)	2,215 (25.03%)
34–43	737 (24.81%)	19 (26.03%)	29 (20.28%)	2,268 (25.62%)
44–51	797 (26.83%)	13 (17.81%)	27 (18.88%)	2,388 (26.98%)
52+	724 (24.37%)	23 (31.51%)	35 (24.48%)	1,980 (22.37%)
Total	2,971 (100.00%)	73 (100.00%)	143 (100.00%)	8,851 (100.00%)

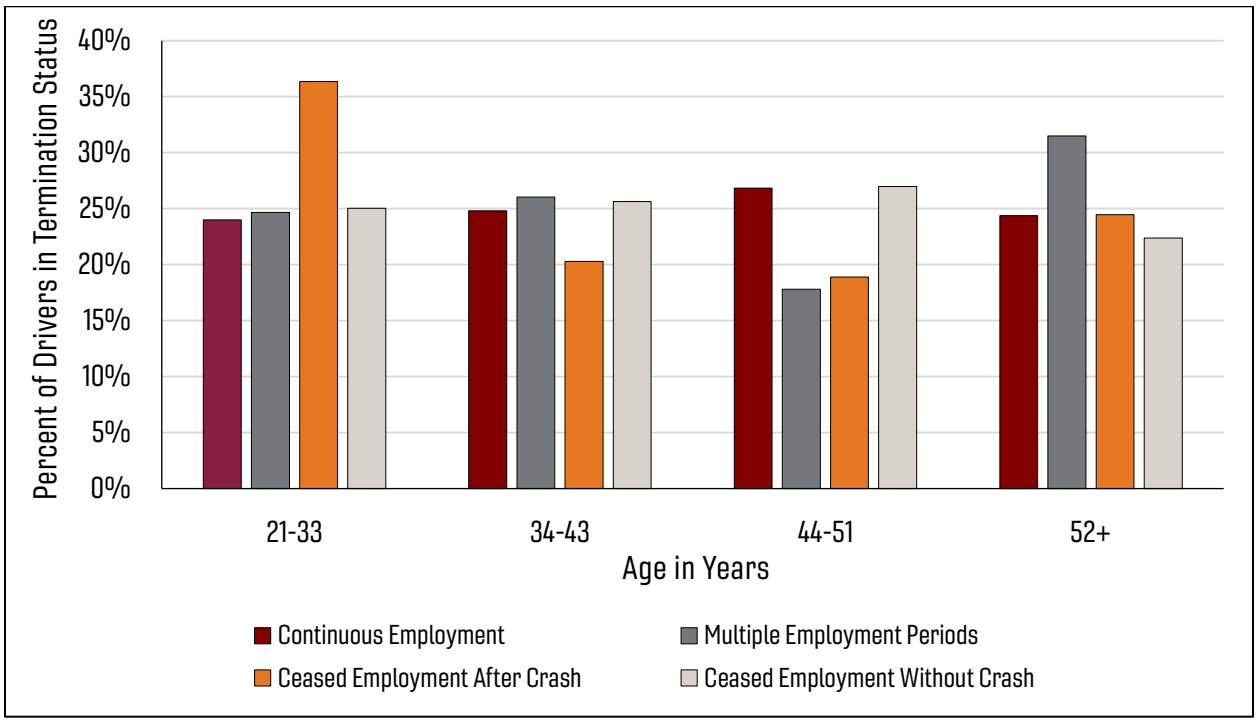

Figure 3. Chart. Distribution of age quartiles by driver termination status.

The distribution of BMI for drivers by employment status is displayed in Table 5. Drivers had similar average BMI in all employment status levels: 32.46 for continuously employed drivers, 31.68 for drivers with multiple employment periods, 32.15 for drivers with ceased employment

following a crash in the preceding 7 days, and 32.44 for drivers with ceased employment without a crash in the preceding 7 days.

Table 5. Distribution of BMI by employment status.

Employment Status	Driver Count	Average BMI	Standard Deviation	Minimum BMI	Maximum BMI
Continuous employment	2,971	32.46	7.48	16.93	68.89
Multiple employment periods	73	31.68	9.69	18.24	86.77
Ceased employment after crash	143	32.15	7.47	20.00	63.13
Ceased employment without crash	8,851	32.44	7.44	15.19	75.31

In each employment status, the number and proportion of drivers in each of the six BMI intervals are included in Table 6 and plotted in Figure 4. Most drivers had BMIs between 25.0 and 35.0, regardless of employment status level. A chi-square test revealed no significant differences in distribution of BMI intervals in the four employment status types (X^2 = 23.1761, p = 0.0805).

Table 6. Distribution of driver frequency by BMI interval.

BMI Interval	Continuous Employment	Multiple Employment Periods	Ceased Employment After Crash	Ceased Employment Without Crash
Drivers with BMI less than 18.5	10 (0.34%)	2 (2.74%)	0 (0.0%)	34 (0.38%)
Drivers with BMI of 18.5–24.9	377 (12.69%)	15 (20.55%)	26 (18.18%)	1,125 (12.70%)
Drivers with BMI of 25–29.9	877 (29.52%)	17 (23.29%)	33 (23.08%)	2,578 (29.11%)
Drivers with BMI of 30.0–34.9	801 (26.96%)	20 (27.40%)	44 (30.77%)	2,455 (27.72%)
Drivers with BMI of 35–39.9	465 (15.65%)	10 (13.70%)	19 (13.29%)	1,388 (15.67%)
Drivers with BMI of 40 and Above	441 (14.84%)	9 (12.33%)	21 (14.69%)	1,271 (14.35%)
Total Number of Drivers with Data	2,971 (100.00%)	73 (100.00%)	143 (100.00%)	8,855 (100.00%)

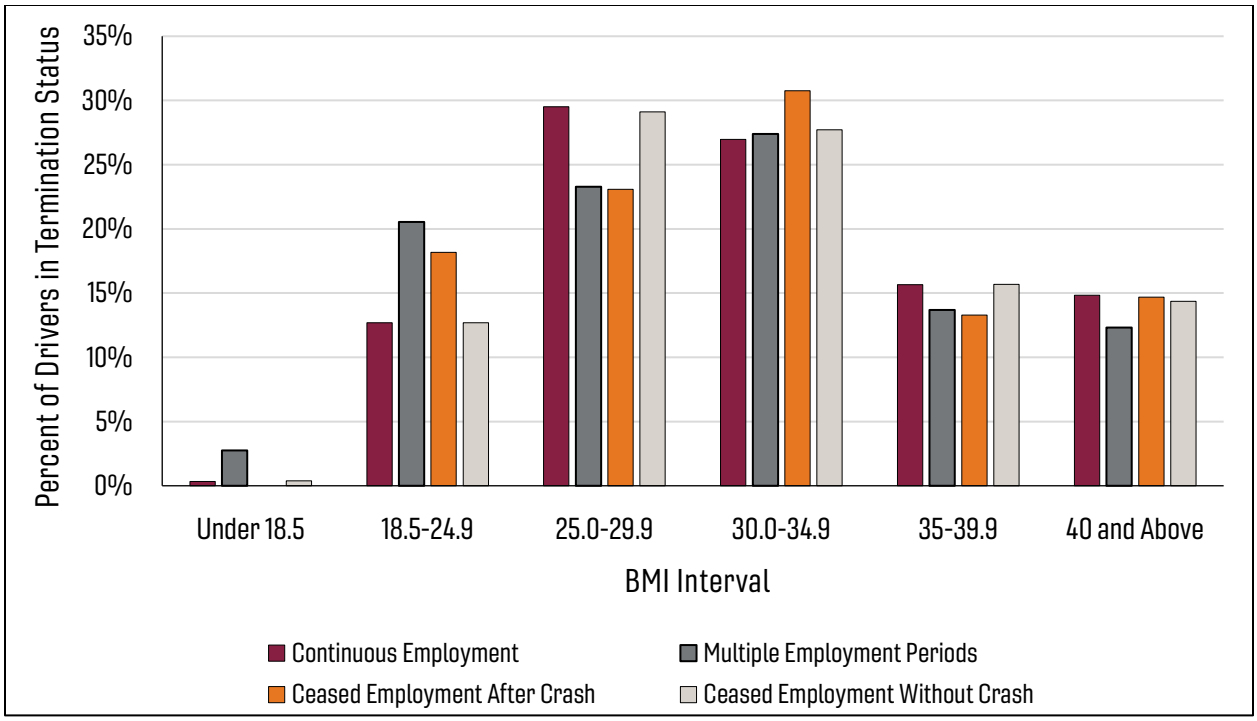

Figure 4. Chart. Distribution of BMI interval categories by driver termination status.

The distribution of recorded gender by employment status level is shown in Table 7. All employment statuses were over 90% male. The percentage of females ranged from 4.11% of drivers with multiple employment periods to 7.69% of drivers with ceased employment within 7 days of a crash. No significant difference was observed in distribution of gender by employment status ($X^2 = 3.70$, $p = 0.2960$).

Table 7. Distribution of reported gender, including missing or unreported values, by employment status.

Employment Status	Driver Count	Male Driver Count (% of Term Type)	Female Driver Count (% of Term Type)
Continuous employment	2,971	2,842 (95.66%)	129 (4.34%)
Multiple employment periods	73	70 (95.89%)	3 (4.11%)
Ceased employment after crash	143	132 (92.31%)	11 (7.69%)
Ceased employment without crash	8,851	8,462 (95.61%)	389 (4.39%)

POISSON REGRESSION MODEL RESULTS FOR SAFETY OUTCOMES BY EMPLOYMENT STATUS

The Poisson regression model results are presented below for safety outcomes of all FMCSA-reportable crashes, FMCSA-reportable injury crashes, and moving violations. Fatal crashes were not included in the analyses due to low crash counts. The results are presented for each age quartile. The model included an offset term for exposure in days. Models were adjusted for age and BMI. The following variables, all self-reported, were considered for inclusion in the model: length of time driver had a Commercial Driver's License (CDL), involvement in a crash in the

past 3 years (yes/no), and involvement in a vehicle violation in the past 3 years (yes/no). The variables length of time driver had CDL and involvement in a crash in the past 3 years did not show a relationship with employment status group. Involvement in a vehicle violation did show a significant relationship with employment status (X^2 = 15.02, p = 0.0201). However, due to the large proportion of missing data for this variable, and that the missing data mainly came from the subset of drivers who chose not to provide survey data, the variable was not included in the model. Violation history and link to driver employment status should be further explored in future studies.

Continuously Employed Drivers vs. Drivers with Ceased Employment with a Recent Crash

Table 8 displays the findings related to differences in overall FMCSA-reportable crashes between continuously employed drivers and drivers with ceased employment with a crash in the preceding 7 days. There were three statistically significant findings.

- Drivers of all ages who were continuously employed were 74.98% less likely to be involved in a national crash than drivers with ceased employment with a crash in the preceding 7 days.
- Drivers aged 21–33 who were continuously employed were 72.66% less likely to be involved in a national crash than drivers with ceased employment with a crash in the preceding 7 days.
- Drivers aged 43–51 who were continuously employed were 89.65% less likely to be involved in a national crash than drivers with ceased employment with a crash in the preceding 7 days.

Table 8. FMCSA-reportable crash risk ratios (RR) and 95% confidence intervals (CIs) comparing continuously employed drivers to drivers with ceased employment with a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Continuously Employed vs. Ceased Employment *with* Crash
FMCSA-reportable Crashes: All Ages	0.2502* (0.1323, 0.4731)
FMCSA-reportable Crashes: 21–33	0.2734* (0.0912, 0.8194)
FMCSA-reportable Crashes: 34–42	-
FMCSA-reportable Crashes: 43–51	0.1035* (0.0382, 0.2806)
FMCSA-reportable Crashes: 52+	0.3094 (0.0710, 1.3494)

Table 9 shows the results comparing FMCSA-reportable injury crashes between continuously employed drivers and drivers with ceased employment with a crash in the preceding 7 days. Once again, there were three statistically significant findings.

- Drivers of all ages who were continuously employed were 86.06% less likely to be involved in a national injury crash than drivers with ceased employment with a crash in the preceding 7 days.
- Drivers aged 21–33 who were continuously employed were 87.28% less likely to be involved in a national injury crash than drivers with ceased employment with a crash in the preceding 7 days.
- Drivers aged 43–51 who were continuously employed were 94.90% less likely to be involved in a national injury crash than drivers with ceased employment with a crash in the preceding 7 days.

Table 9. FMCSA-reportable injury crash RRs and 95% CIs comparing continuously employed drivers to drivers with ceased employment after a crash.

Safety Outcome and Age Quartile	RR (CI) for Continuously Employed vs. Ceased Employment w*ith* Crash
FMCSA-reportable Injury Crashes: All Ages	0.1394* (0.0600, 0.3238)
FMCSA-reportable Injury Crashes: 21–33	0.1272* (0.0317, 0.5112)
FMCSA-reportable Injury Crashes: 34–42	-
FMCSA-reportable Injury Crashes: 43–51	0.0510* (0.0122, 0.2137)
FMCSA-reportable Injury Crashes: 52+	0.1861 (0.0216, 1.6015)

Table 10 shows the results comparing the violations between continuously employed drivers and drivers with ceased employment with a crash in the preceding 7 days. As shown in Table 10, there were two statistically significant findings.

- Drivers of all ages who were continuously employed were 51.22% less likely to be involved in a violation than drivers with ceased employment with a crash in the preceding 7 days.
- Drivers aged 21–33 who were continuously employed were 61.72% less likely to be involved in a violation than drivers with ceased employment with a crash in the preceding 7 days.

Table 10. Moving violation RRs and 95% CIs comparing continuously employed drivers to drivers with ceased employment after a crash.

Safety Outcome and Age Quartile	RR (CI) for Continuously Employed vs. Ceased Employment *with* Crash
Violations: All Ages	0.4878* (0.2878, 0.8268)
Violations: 21–33	0.3828* (0.1804, 0.8122)
Violations: 34–42	0.6702 (0.1623, 2.7669)
Violations: 43–51	0.4001 (0.1238, 1.2933)
Violations: 52+	0.8150 (0.1974, 3.3651)

Continuously Employed Drivers vs. Drivers with Ceased Employment Without a Recent Crash

There were four statistically significant findings comparing the overall FMCSA-reportable crashes of continuously employed drivers to drivers with ceased employment *without* a crash in the preceding 7 days (Table 11).

- Drivers of all ages who were continuously employed were 64.53% less likely to be involved in a national crash than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 21–33 who were continuously employed were 65.59% less likely to be involved in a national crash than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 43–51 who were continuously employed were 67.29% less likely to be involved in a national crash than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 52+ who were continuously employed were 65.75% less likely to be involved in a national crash than drivers with ceased employment without a crash in the preceding 7 days.

Table 11. FMCSA-reportable crash RRs and 95% CIs comparing continuously employed drivers to drivers with ceased employment without a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Continuously Employed vs. Ceased Employment *Without a* Recent Crash
FMCSA-reportable Crashes: All Ages	0.3547 * (0.2755, 0.4567)
FMCSA-reportable Crashes: 21–33	0.3441* (0.2049, 0.5778)
FMCSA-reportable Crashes: 34–42	-
FMCSA-reportable Crashes: 43–51	0.3271* (0.1978, 0.5410)
FMCSA-reportable Crashes: 52+	0.3425* (0.2031, 0.5777)

Similarly, there were four statistically significant comparisons of FMCSA-reportable injury crashes between continuously employed drivers and drivers with ceased employment without a crash within the previous 7 days (Table 12).

- Drivers of all ages who were continuously employed were 65.56% less likely to be involved in a national injury crash than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 21–33 who were continuously employed were 66.29% less likely to be involved in a national injury crash than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 43–51 who were continuously employed were 68.09% less likely to be involved in a national injury crash than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 52+ who were continuously employed were 69.73% less likely to be involved in a national injury crash than drivers with ceased employment without a crash in the preceding 7 days.

Table 12. FMCSA-reportable injury crash RRs and 95% CIs comparing continuously employed drivers to drivers with ceased employment without a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Continuously Employed vs. Ceased Employment *Without a* Recent Crash
National Injury Crashes: All Ages	0.3444* (0.2252, 0.5266)
FMCSA-reportable Injury Crashes: 21–33	0.3371* (0.1447, 0.7857)
FMCSA-reportable Injury Crashes: 34–42	-
FMCSA-reportable Injury Crashes: 43–51	0.3191* (0.1264, 0.8058)
FMCSA-reportable Injury Crashes: 52+	0.3027* (0.1196, 0.7661)

All comparisons of violations between continuously employed drivers and drivers with ceased employment without a crash in the previous 7 days were statistically significant (Table 13).

- Drivers of all ages who were continuously employed were 43.74% less likely to be involved in a violation than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 21–33 who were continuously employed were 51.37% less likely to be involved in a violation than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 34–42 who were continuously employed were 47.32% less likely to be involved in a violation than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 43–51 who were continuously employed were 42.02% less likely to be involved in a violation than drivers with ceased employment without a crash in the preceding 7 days.
- Drivers aged 52+ who were continuously employed were 30.26% less likely to be involved in a violation than drivers with ceased employment without a crash in the preceding 7 days.

Table 13. Moving violation RRs and 95% CIs comparing continuously employed drivers to drivers with ceased employment without a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Continuously Employed vs. Ceased Employment *Without a* Recent Crash
Violations: All Ages	0.5626* (0.4779, 0.6623)
Violations: 21–33	0.4863* (0.3558, 0.6646)
Violations: 34–42	0.5268* (0.3803, 0.7297)
Violations: 43–51	0.5798* (0.4121, 0.8158)
Violations: 52+	0.6974* (0.5010, 0.9708)

Drivers with Ceased Employment Without a Recent Crash vs. Drivers with Ceased Employment with a Recent Crash

There was only one statistically significant result when comparing the number of FMCSA-reportable crashes for drivers with ceased employment *without* a recent crash to drivers with ceased employment *after* being involved in a recent crash (Table 14). Drivers aged 43–51 with ceased employment *without* a crash in the preceding 7 days were 68.36% less likely to be involved in a national crash than drivers with ceased employment *with* a crash in the preceding 7 days.

Table 14. FMCSA-reportable RRs and 95% CIs comparing drivers with ceased employment without a crash to drivers with ceased employment with a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Ceased Employment *without* Recent Crash vs. Ceased Employment *with* Recent Crash
FMCSA-reportable Crashes: All Ages	0.7053 (0.3881, 1.2817)
FMCSA-reportable Crashes: 21–33	0.7946 (0.2934, 2.1517)
FMCSA-reportable Crashes: 34–42	-
FMCSA-reportable Crashes: 43–51	0.3164* (0.1297, 0.7719)
FMCSA-reportable Crashes: 52+	0.9033 (0.2227, 3.6644)

There were two statistically significant results comparing the FMCSA-reportable injury crashes of drivers with ceased employment without a recent crash to drivers with ceased employment after a crash within the previous 7 days (Table 15).

- Drivers of all ages with ceased employment without a crash in the preceding 7 days were 59.52% less likely to be involved in a national injury crash than drivers with ceased employment with a crash in the preceding 7 days.
- Drivers aged 43–51 with ceased employment without a crash in the preceding 7 days were 84.01% less likely to be involved in a national injury crash than drivers with ceased employment with a crash in the preceding 7 days.

Table 15. FMCSA-reportable RRs and 95% CIs comparing drivers with ceased employment without a recent crash to drivers with ceased employment after a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Ceased Employment *without* Recent Crash vs. Ceased Employment *with* Recent Crash
FMCSA-reportable Injury Crashes: All Ages	0.4048* (0.1903, 0.8611)
FMCSA-reportable Injury Crashes: 21–33	0.3774 (0.1171, 1.2157)
FMCSA-reportable Injury Crashes: 34–42	-
FMCSA-reportable Injury Crashes: 43–51	0.1599* (0.0496, 0.5157)
FMCSA-reportable Injury Crashes: 52+	0.6147 (0.0841, 4.4926)

There were no differences in violations between drivers with ceased employment without a recent crash and drivers with ceased employment after a crash in the previous 7 days (Table 16).

Table 16. Moving violation RRs and 95% CIs comparing drivers with ceased employment without a recent crash to drivers with ceased employment after a recent crash.

Safety Outcome and Age Quartile	RR (CI) for Ceased Employment *without* Recent Crash vs. Ceased Employment *with* Recent Crash
Violations: All Ages	0.8670 (0.5203, 1.4448)
Violations: 21–33	0.7873 (0.3893, 1.5921)
Violations: 34–42	1.2723 (0.3162, 5.1188)
Violations: 43–51	0.6900 (0.2205, 2.1589)
Violations: 52+	1.1685 (0.2893, 4.7203)

Continuously Employed Drivers vs. Drivers with Multiple Employment Periods

There are two statistically significant findings in Table 17 comparing continuously employed drivers to drivers with multiple employment periods. Comparisons across individual age groupings were not possible as there were only 73 drivers with multiple employment periods.

- Drivers of all ages who were continuously employed were 74.65% less likely to be involved in a national crash than drivers with multiple employment periods.
- Drivers of all ages who were continuously employed were 61.76% less likely to be involved in a violation than drivers with multiple employment periods.

Table 17. RRs and 95% CIs comparing continuously employed drivers to drivers with multiple employment periods.

Safety Outcome	RR (CI) for Continuously Employed vs. Multiple Employment Periods
FMCSA-reportable Crashes: All Ages	0.2535* (0.1100, 0.5842)
FMCSA-reportable Injury Crashes: All Ages	0.2638 (0.0623, 1.1163)
Violations: All Ages	0.3824* (0.2021, 0.7234)

Drivers with Ceased Employment Without a Recent Crash vs. Drivers with Multiple Employment Periods

No significant differences were observed in the comparison of drivers with ceased employment without a recent crash and drivers with multiple employment periods. Findings from the models are in Table 18.

Table 18. RRs and 95% CIs comparing drivers with ceased employment without a recent crash to drivers with multiple employment periods.

Safety Outcome	RR (CI) for Ceased Employment *without* Recent Crash vs. Multiple Employment Periods
FMCSA-reportable Crashes: All Ages	0.7146 (0.3195, 1.5984)
FMCSA-reportable Injury Crashes: All Ages	0.7659 (0.1901, 3.0855)
Violations: All Ages	0.6797 (0.3643, 1.2680)

Drivers with Ceased Employment After a Recent Crash vs. Drivers with Multiple Employment Periods

Similarly, no significant differences were observed in crash and violation rates for drivers with ceased employment after a recent crash and drivers with multiple employment periods. Model results are listed in Table 19.

Table 19. RRs and 95% CIs comparing drivers with multiple employment periods to drivers with ceased employment with a recent crash.

Safety Outcome	RR (CI) for Multiple Employment Periods vs. Ceased Employment with Recent Crash
FMCSA-reportable Crashes: All Ages	0.9869 (0.3648, 2.6699)
FMCSA-reportable Injury Crashes: All Ages	0.5286 (0.1097, 2.5464)
Violations: All Ages	1.2757 (0.5729, 2.8406)

ANALYSIS OF SAFETY OUTCOMES BY CRASH TYPE

Safety outcomes for drivers with ceased employment after a recent preventable versus non-preventable and FMCSA-reportable versus non-FMCSA-reportable crash were compared. For comparisons with enough data, Poisson regression models were used to compare FMCSA-reportable crashes, FMCSA-reportable injury crashes, and moving violation rates for drivers with ceased employment after a recent crash by crash type.

Ceased Employment After a Preventable vs. Non-preventable Crash

Crashes recorded in the carrier crash data set were marked as preventable or non-preventable by the participating carrier. Of the 143 drivers with ceased employment after a crash, 118 (82.52%) ceased employment following a preventable crash. Another nine (6.29%) ceased employment following a non-preventable crash. A determination of preventability was missing for 16 drivers (11.19%). As very few drivers ceased employment following a non-preventable crash, no further

formal analysis was conducted. Table 20 below includes the driver counts and average rates of crashes and violations for these groups.

Table 20. Driver count and average crash and violation rates for drivers with ceased employment after a crash, by termination crash preventability status.

Preventability	Driver Count	Average Crash Rate/Year	Average Injury Crash Rate/Year	Average Violation Rate/Year
Preventable	118 (82.52%)	0.0371	0.0301	0.0580
Non-preventable	9 (6.29%)	0.0000	0.0000	0.0629
Missing or Unknown	16 (11.19%)	0.0988	0.0248	0.0253

Ceased Employment After FMCSA-reportable vs. Non-FMCSA-reportable Crash

Crashes recorded in the carrier crash data set were marked as FMCSA-reportable or not FMCSA-reportable, and all crashes recorded in MCMIS were FMCSA-reportable. The 143 drivers with ceased employment after a crash included 46 (32.17%) with ceased employment after an FMCSA-reportable crash and 97 (67.83%) with ceased employment after a non-FMCSA-reportable crash. Driver counts and average crash and violation rates for these two groups are shown in Table 21.

Table 21. Driver count and average crash and violation rates for drivers with ceased employment after a crash, by crash type.

Crash Type	Driver Count	Average Crash Rate/Year	Average Injury Crash Rate/Year	Average Violation Rate/Year
FMCSA-reportable	46 (32.17%)	0.0712	0.0371	0.0462
Non-FMCSA-reportable	97 (67.83%)	0.0277	0.0231	0.0592

Poisson regression models compared crash and violation rates for drivers with ceased employment after an FMCSA-reportable or non-reportable crash. The results are included in Table 22. No significant differences were identified.

Table 22. RRs and 95% CIs comparing drivers with ceased employment after an FMCSA-reportable crash and drivers with ceased employment after a non-FMCSA-reportable crash.

Safety Outcome	RR (CI) for Ceased Employment After Non-FMCSA-reportable Crash vs. After FMCSA-reportable Crash
FMCSA-reportable Crashes: All Ages	0.3665 (0.1112, 1.2075)
FMCSA-reportable Injury Crashes: All Ages	0.5991 (0.1331, 2.6954)
Violations: All Ages	1.3346 (0.4237, 4.2036)

CHAPTER 5. DISCUSSION

Although some research has examined the relationship between turnover and safety, there is a paucity of research investigating differences between voluntary and involuntary turnover on safety performance. Understanding these differences is critical for carriers given high rates of turnover in the industry, much of which is the result of drivers voluntarily leaving carriers. The purpose of this study was to address this gap in knowledge. Specifically, this study examined the relationship between voluntary and involuntary driver turnover with involvement in future FMCSA-reportable crashes and moving violations.

Results from this study show that, overall, drivers with continuous employment had a lower risk of being involved in a crash or receiving a violation compared to drivers with ceased employment following a crash and drivers that left the carrier without a recent crash. These results were consistent across many of the age quartiles. More specifically, crash and violation risk was lowest for drivers that stayed with the same carrier, rose for drivers that left the carrier without a recent crash, and rose again for drivers that left the carrier following a recent crash within the previous 7 days. Furthermore, there were few significant differences between drivers that left the carrier without a recent crash, drivers that left with ceased employment following a crash, and drivers that left the carrier and were subsequently rehired during the 3 years of data collection. Finally, drivers in the 43–51 age quartile were consistently the safest drivers.

These results support much of the previous research showing a relationship between high turnover rates and higher crash rates (Corsi & Fanara, 1988). Although this study did not compare carriers with varying levels of turnover, these results support evidence that carriers that maintain high levels of retention likely experience lower crash rates. Additionally, these results support findings from Staplin and Gish (2005). Staplin and Gish found that CMV drivers who changed employers multiple times each year for multiple years were involved in more crashes compared to drivers that did not change employers as frequently. Although this study could not fully assess how many employers the drivers worked for after termination, we did find that all drivers who switched jobs were involved in significantly more crashes than those who did not, including drivers who left the carrier and were rehired multiple times over the 3-year data collection window.

Finally, data from this study show the prevalence of voluntary turnover. Gupta et al. (1996) and Shaw et al. (1998) found that voluntary turnover was 4 times higher than involuntary driver turnover. This study supports the observation that voluntary turnover is much more prevalent than involuntary turnover, under the assumption that leaving the carrier without a recent crash was voluntary. However, the participating carrier in this study experienced much higher rates of voluntary turnover. There were over 8,000 drivers who left the carrier without being involved in a crash compared to approximately 150 drivers that were fired following a crash. Although some of the 8,000 drivers may have been fired for cause (but not after a crash), it is likely many of those 8,000 drivers simply chose to leave the carrier for personal reasons.

IMPLICATIONS OF RESULTS

The results from this study likely have significant implications on carrier policies and programs associated with driver retention, including policies related to compensation, benefits, routing,

management communication, and culture (Suzuki et al., 2009). Carriers should develop a comprehensive approach to improve driver retention (Williams, et al., 2011). Policies and programs should target drivers' primary needs (e.g., pay, home time, etc.), organizational relationships (e.g., management support, responsiveness, etc.), and career advancement (e.g., opportunities for growth).

Previous research has found that compensation packages are the leading contributor to voluntary turnover for CMV drivers (Stephenson & Fox, 1996; Dobie et al., 1998; Keller & Ozment, 1999; Min & Lambert, 2002; Keller, 2002; Suzuki et al., 2009). The compensation package offered by carriers is more than simply pay per mile. It includes driver benefits, preferential routes, well-maintain equipment, new trucks, time off per week, etc. Carriers can work with individual drivers to determine the most-valued compensation components to encourage retention. Although these may increase carrier operational costs, previous research has shown that these costs were outweighed by the savings from reduced crashes (Faulkiner, 2016). Results from this study provide justification that savings from fewer crashes may outweigh an increased compensation package to improve driver retention.

Compensation is not the only factor that contributes to drivers' decisions to stay with a carrier. Organizational relationships, especially dispatcher relationships, are critical to determining a driver's job satisfaction. Keller and Ozment (1999a; 1999b) found that dispatchers have a large influence on driver retention. Similarly, Keller (2002) surveyed motor carrier dispatchers and found that driver retention is highly correlated to how responsive dispatchers are to driver concerns. Additionally, Camden et al. (2019) found that carriers with programs to encourage positive relationships with drivers significantly improved safety performance. Thus, carriers need to create policies and programs to encourage supportive dispatcher-driver relationships. This includes actively listening to and addressing driver concerns, creating a family atmosphere, discouraging dispatcher practices that encourage drivers to operate while fatigued, and supporting drivers in rescheduling due to delays and detention time.

SUMMARY

This study provides evidence demonstrating the safety implications of drivers frequently changing jobs. Overall, drivers that remained with a carrier over 3 years were nearly 75% less likely to be involved in a future serious crash compared to drivers whose employment ceased within 7 days after a recent crash. Furthermore, drivers that stayed with the carrier were approximately 65% less likely to be involved in a serious crash compared to drivers that left the carrier without being involved in a crash (i.e., voluntary turnover). Finally, there were few differences in crashes between all drivers that left the carrier. Thus, carriers should focus recruitment efforts on drivers with a stable employment history, and carefully create comprehensive programs and policies to encourage safe drivers to remain.

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