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A Preliminary Investigation into the Safety-Critical Event Risk of Aging Commercial Motor Vehicle Drivers

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ABSTRACT

The majority of research into age-related declines in driving performance has concentrated on light vehicle, non-commercial drivers. However, the aging of the commercial motor vehicle (CMV) workforce raises a number of important questions regarding the potential impact of age-related declines in perceptual, cognitive, and psychomotor performance on the ability to safely operate a CMV. The current study offers a secondary analysis of four existing naturalistic truck driving studies examining the safety-critical event risk of younger CMV drivers (30 to 40 years old) versus older drivers (50+ years old). Results for the initial analysis show that the younger and older driver groups did not differ significantly from each other, with the exception that the younger drivers had 2.4 times the odds of being involved in an at-fault near-crash. Additional comparisons were also conducted between younger drivers (30 to 40 years old), older drivers (50 to 64 years old), and the oldest drivers (65 years old or older), though the sample size of six drivers for the oldest drivers group was small. Results for the second analysis indicate that the SCE, at-fault SCE, near-crash, and crash-relevant conflict rates did not differ significantly between the younger, older, and oldest driver groups. Crash rates also did not differ significantly, though this needs to be interpreted with caution due to the small number of crashes in the final data set. In general, the results provide evidence that older (50 to 64 years old) drivers are as safe behind the wheel as their younger counterparts. Due to the small sample size for the oldest driver group (65+ years old), the preliminary impression that they are as safe as the other two groups cannot be statistically tested or confirmed.

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LIST OF ABBREVIATIONS AND SYMBOLS

CMV	commercial motor vehicle
C/VIS	Camera/Video Imaging System
DAS	data acquisition system
DDWS FOT	Drowsy Driver Warning System Field Operational Test
FAST DASH	Federal Motor Carrier Safety Administration’s Advanced System utilizing a Data Acquisition System on the Highways
ND	naturalistic driving
NTDS	Naturalistic Truck Driving Study
SCE	safety-critical event
UFOV	useful field of view
VMT	vehicle miles traveled

CHAPTER 1. INTRODUCTION

The commercial motor vehicle (CMV) driver population is an aging workforce, with the average age of a truck driver currently sitting at 49 years.(1) Further, the industry-wide average age is increasing at a greater rate than the rate of the overall workforce,(2) which means the trucking industry faces a looming driver shortage issue as more and more truck drivers retire. According to the American Trucking Associations, in 2014, the trucking industry was short 38,000 drivers, with current trends indicating that the shortage may balloon to almost 175,000 drivers by 2024. Over the next decade, the trucking industry will need to hire an average of 89,000 drivers annually to mitigate this shortage. Replacing retiring truck drivers will be the largest factor, accounting for nearly half of new driver hires.(1) Strict hiring criteria by many motor carriers, based primarily on driving history and experience, can make it difficult to replace high-quality, experienced drivers; thus, there may be clear advantages to retaining older CMV drivers into their 50s, 60s, and beyond.

The advantages of retaining aging CMV drivers, however, are highly dependent on these drivers' ability to continue performing critical driving tasks safely as they age. Previous research has indicated that age-related declines occur in perceptual, cognitive, and psychomotor performance, all of which are relevant to driving.(3,4) The most important perceptual abilities related to driving are visual abilities, with approximately 85% to 90% of driving-related information conveyed via visual input.(5) Visual deterioration becomes more prevalent with advancing age, which can greatly impact visual acuity, contrast sensitivity, useful field of view (UFOV), and depth perception, all of which are important for safe driving.(2) Cognitive abilities that undergo age-related changes include decision making, selective attention, attention sharing, and general information processing, each of which is vital to a driver's capacity to process the enormous amount of incoming information specific to the driving task.(4) Psychomotor abilities may appear to be of minor importance relative to perceptual and cognitive performance; however, psychomotor demands may be greater for CMV drivers due to the larger size of the vehicles they drive. Psychomotor abilities, such as range of motion, reaction time, coordination, precision, and tracking, all of which are important to the driving task, all also show age-related declines.(4) Indeed, Ball et al.(6) found that a number of performance-based measures were predictive of future at-fault crashes in older adults. Cognitive performance, in particular, was a salient predictor of subsequent crash involvement, as was age, sex, and history of falls.

Although these age-related changes in perceptual, cognitive, and psychomotor performance are inevitable, the onset, amount, and rate of decline varies widely among individuals. Two people of the exact same age will not necessarily exhibit the same decrements in their abilities. Their vision, cognition, and psychomotor functioning depends on an array of factors outside of age alone. In addition, different abilities deteriorate at different rates. Llaneras et al.(4) found that dynamic visual acuity and field dependence deteriorated as early as 55 years of age, while decrements in static acuity and contrast sensitivity were only apparent by 65 years of age. The ability that showed the most substantial age-related change in performance was UFOV, with older individuals tending to have greater reductions in their UFOV. Thus, overall driving performance cannot be reliably indexed by chronological age alone. Rather, age appears to act as a moderator variable that indirectly influences driving performance via the impact it has on intervening variables, such as the aforementioned perceptual, cognitive, and psychomotor abilities.(4)

In addition to age-related declines, there are a whole host of medical conditions that become more prevalent with age, which may directly or indirectly compromise critical safe-driving abilities (e.g., cataracts, glaucoma, macular degeneration, diabetes, stroke, dementia, arthritis). Ironically, prescription and some over-the-counter medications intended to help with these conditions may also simultaneously negatively impact an individual's ability to drive safely via their effects on the central nervous system, blood sugar levels, blood pressure, vision, and cognition. Adverse drug events requiring hospitalizations are more common in older adults, indicating they may not necessarily be aware of the side-effects of the medications they take or the risks of polypharmacy, if they take multiple medications.(2) As a safeguard against some of these factors, CMV drivers are required to undergo a biennial medical exam to determine their fitness to drive. However, the medical exam may not cover critical age-related, performance-affecting factors, such as declines in visual ability (e.g., contrast sensitivity), cognition (e.g., processing speed), perceptual-cognitive ability (e.g., UFOV), and psychomotor functions (e.g., reaction time), that may be associated with increased crash risk.(2,4) These facts all highlight a need for further investigation into the safety-critical event (SCE) risk of older CMV drivers.

Despite the obvious potential for safety implications, research on this topic of emerging importance is limited. The vast majority of the work that has been done on aging drivers has focused on light vehicle, non-commercial drivers, so there are still many unknowns when it comes to the older CMV driver population and their unique driving environment and tasks. According to the Virginia Department of Motor Vehicles, for non-commercial drivers, the "elbow" in the SCE curve (i.e., where we tend to see an uptick in age-related event rates) is around 70 years of age.(7) However, due to CMV drivers' greatly increased driving demands and drastically different driving environment, their age-related "elbow" may occur at a much younger age. Indeed, Duke et al.(8) found that crash/fatality involvement rates increased after the age of 63 years in CMV drivers. Ball et al.(9) analyzed crash statistics for commercial drivers and results indicated that CMV drivers aged 66 years and older were 6.64 times more likely to be involved in a fatal crash and 4.25 times more likely to be involved in an injurious crash than CMV drivers aged 46 to 55 years (which were the safest group). The CMV industry currently views older drivers in the same light as the rest of the CMV driver population; their age alone does not afford them differential treatment in terms of scheduling, hiring, or assignments. However, as older CMV drivers most often have seniority, they do frequently have shorter or less-demanding routes, which may tend to mask the underlying effects of aging.(2) Older drivers may also be more likely to self-regulate their driving habits to avoid situations they find risky. For example, they may avoid driving at night or in bad weather to compensate for their ability deficits. They are also more likely to possess an abundance of driving experience that offsets aging effects, particularly if they have been a CMV driver for their entire working life. Despite these compensatory factors that may contribute to industry professionals' perception that older CMV drivers are not higher risk than younger CMV drivers,(10) there exists a need in today's ever-changing workforce to investigate the reality underlying this perception.

The current study was a secondary analysis of four existing truck-based naturalistic driving (ND) data sets. The initial analysis plan was to compare the SCE rates of older CMV drivers (65+ years of age) to mature younger CMV drivers (30–40 years of age); however, a review of the data sets revealed only six drivers aged 65 years and over. Thus, in order to increase the sample size of the older driver group, the age range was revised to 50+ years of age. However, given that the original plan was to focus on drivers who were 65 years and over, combined with the possibility that age-related decrements in driving performance may not occur as early as 50 years of age, additional analyses were also conducted on the drivers who were 65+ years of age. This allowed for comparisons between the younger drivers (30–40 years), older drivers (50–64 years), and oldest drivers (65+ years). The primary aim of this study was to investigate the SCE risk of aging CMV drivers. Crash, near-crash, and crash-relevant conflict rates were calculated for each age group in order to determine if aging CMV drivers do pose a greater safety risk on the roads.

CHAPTER 2. METHODS

OVERVIEW OF THE DATA SETS USED IN THE CURRENT STUDY

The data from the four truck-based ND studies used in the current study were collected using a data acquisition system (DAS) designed and developed by Virginia Tech Transportation Institute (VTTI). The DAS allows for the continuous collection of driver and roadway video, as well as parametric data pertaining to the vehicle, its location, and its distance to surrounding objects, over an extended period of time. Thus, ND studies present researchers with the unique opportunity to directly observe driver behavior and vehicle status in the lead up to a crash or near-crash. SCEs of interest included crashes, near-crashes, and crash-relevant conflicts. Following is a brief description of each ND data set included in the current study.

The Drowsy Driver Warning System Field Operational Test (DDWS FOT)

The Drowsy Driver Warning System Field Operational Test (DDWS FOT) was the largest ND CMV study ever conducted by the U.S. Department of Transportation, with more than 12 terabytes of kinematic and video data collected. Data were collected for 18 months from 103 drivers of 46 instrumented trucks. The resulting database contains approximately 2.3 million miles traveled. See Blanco et al.[(11)] for a complete description of the DDWS FOT.

The Naturalistic Truck Driving Study (NTDS)

The Naturalistic Truck Driving Study (NTDS) was another ND truck study that collected more than 4 terabytes of kinematic and video data. The NTDS collected continuous driving data from 100 drivers of nine instrumented trucks, with each driver being observed for approximately four consecutive workweeks. The resulting database contains approximately 735,000 miles of driving data. See Blanco et al.[(12)] for a complete description of the NTDS.

The Field Demonstration of Heavy Vehicle Camera/Video Imaging Systems (C/VIS)

The Field Demonstration of Heavy Vehicle Camera/Video Imaging Systems (C/VIS) study was conducted to evaluate the benefits and disbenefits of implementing C/VISs in real-world trucking operations. A total of 3.62 terabytes of data were collected over a 12-month period from 12 CMV drivers of six instrumented trucks, with each driver being observed for 4 months. The resulting database contains approximately 278,000 miles of driving data. See Fitch et al.[(13)] for a complete description of the C/VIS study.

Federal Motor Carrier Safety Administration's Advanced System utilizing a Data Acquisition System on the Highways (FAST DASH)

The purpose of the ongoing Federal Motor Carrier Safety Administration's Advanced System utilizing a Data Acquisition System on the Highways (FAST DASH) study was to evaluate safety technologies aimed at improving CMV operations. Data from Phase I were collected over an 11-month period from 21 drivers of 20 instrumented trucks, with each driver being observed for 6 months. The resulting database contains approximately 722,000 miles of driving data. See Schaudt et al.[(14)] for a complete description of FAST DASH.

DATA SET FORMATTING

Prior to any analyses, the data were formatted and merged into one data set, which comprised SCEs categorized as follows:[13]

- *Crash:* Any contact with an object, either moving or fixed, at any speed in which kinetic energy is measurably transferred or dissipated. This also includes non-premeditated departures of the roadway where at least one tire leaves the paved or intended travel surface of the road, as well as instances where the subject vehicle strikes another vehicle, roadside barrier, pedestrian, cyclist, animal, or object on or off the roadway.
- *Near-Crash:* Any circumstance requiring a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal, to avoid a crash, or any circumstance that results in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver(s), pedestrian(s), cyclist(s), or animal(s), there is no avoidance maneuver or response. A rapid evasive maneuver is defined as steering, braking, accelerating, or any other combination of control inputs that approaches the limits of the vehicle's capabilities.
- *Crash-Relevant Conflict:* Any circumstance that requires a crash-avoidance response on the part of the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal, that is less severe than a rapid evasive maneuver (as defined above) but greater in severity than a "normal maneuver" to avoid a crash, or any circumstance that results in close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver(s), pedestrian(s), cyclist(s), or animal(s), there is no avoidance maneuver or response. A crash-avoidance response can include braking, steering, accelerating, or any combination of control inputs.

DATA ANALYSIS

The final data set included CMV drivers from four existing naturalistic truck driving studies. For the purpose of the current study, two separate analyses were completed. Due to the low number of drivers who were over the age of 65 years, the initial analyses focused on two groups of drivers who were selected based on age. The older CMV driver group included all drivers who were 50 years of age and over, and the younger CMV driver group included all drivers who were in the 30- to 40-year age bracket. SCE data linked to each driver in the older and younger groups were compiled and the total miles driven for each group was calculated. Analyses included descriptives of the two age groups, such as mean age and driving experience, and inferential statistics to determine differences between the two age groups, such as odds ratios and SCE rates per 1,000 vehicle miles traveled (VMT). In order to address the possibility that driving performance decrements may not appear until the age of 65 years and over, additional analyses were completed using three age groups, namely the younger drivers (30–40 years), older drivers (50–64 years), and oldest drivers (65+ years).

CHAPTER 3. RESULTS

PART I: YOUNGER DRIVERS VERSUS OLDER DRIVERS

The final data set included 71 younger drivers (30–40 years of age) and 65 older drivers (50+ years of age). The younger drivers' average age was 35.5 years (SD = 2.9) and they had an average of 7.9 years of CMV driving experience (SD = 5.6). The older drivers' average age was 55.9 years (SD = 5.8) and they had an average of 17.5 years of CMV driving experience (SD = 12.0). The distribution of CMV driving experience is shown for younger and older drivers in Figure 1. Because the driving experience data had a left skewed distribution, a log transformation was applied before analysis using a two-sample *t*-test. The two age groups were found to have statistically different mean years of CMV driving experience ($\alpha = 0.05$, $t_{133} = 4.13$, $p < 0.0001$); however, the age range of younger driver group was bound to 10 years (i.e., 30–40 years of age) whereas the older group was not (i.e., 50+ years). Thus, this imposed a maximum value for driving experience for the younger group, as a 40-year-old driver cannot have any more than approximately 22 years of driving experience.

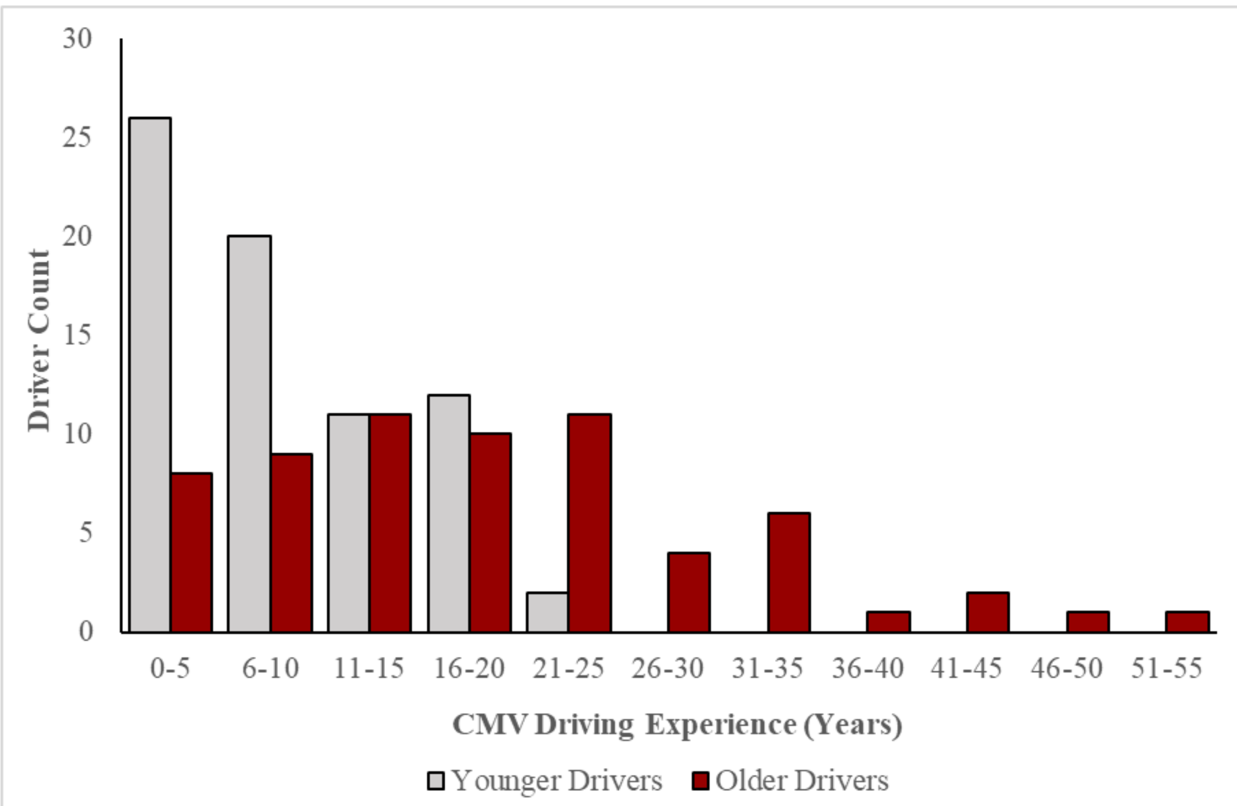

Figure 1. Bar graph. Distribution of CMV driving experience in years for younger and older drivers.

The SCE types common to all the included studies were crashes, near-crashes, and crash-relevant conflicts. The distribution of these SCE types in the two age groups is described in Table 1 below. The younger driver group had a total of 1,272 SCEs, while the older driver group had a total of 807 SCEs. Over 90% of SCEs for both groups were crash-relevant conflicts and each group had very few crashes. A chi-square test of independence was used to test for differences in the SCE type distributions in the two groups (i.e., did the groups differ in their SCE breakdown in terms of proportions of crashes, near-crashes, and crash-relevant conflicts?). The two age groups were not found to have a statistically different distribution of SCE types ($\alpha = 0.05$, $\chi^2 = 1.4585$, $p = 0.4823$).

Table 1. Distribution of SCEs in younger and older driver groups.

SCE Type	Younger Drivers		Older Drivers	
	SCE Count	Proportion of All SCEs	SCE Count	Proportion of All SCEs
Crashes	11	0.9%	9	1.1%
Near-Crashes	81	6.4%	61	7.6%
Crash-Relevant Conflicts	1,180	92.8%	737	91.3%
Total	1,272	100.0%	807	100.0%

Table 2 shows the distribution and proportion of SCEs for the two age groups where the subject driver (i.e., the driver of the instrumented vehicle) was deemed to be at-fault. This "at-fault" determination was made by data reductionists at VTTI who viewed and coded all the SCEs for each of the studies. Based on the characteristics of the SCE, the reductionist designated the SCE as the fault of the subject driver (e.g., did not stop at a stop sign), another vehicle (e.g., Vehicle 2 swerved into the subject driver's lane), or no fault (e.g., deer or other animal on the road). A chi-square test of independence was used to test for differences in the at-fault SCE type distributions in the two groups (i.e., did the groups differ in their proportions of at-fault crashes, near-crashes, and crash-relevant conflicts amongst their SCEs?). The two age groups were not found to have a statistically different distribution of at-fault SCE types ($\alpha = 0.05$, $\chi^2 = 1.1567$, $p = 0.5608$).

Table 2. Distribution of at-fault SCEs in younger and older driver groups.

SCE Type	Younger Drivers			Older Drivers		
	At-Fault SCE Count	Proportion of At-Fault SCEs	Proportion of SCEs Deemed At-Fault	At-Fault SCE Count	Proportion of At-Fault SCEs	Proportion of SCEs Deemed At-Fault
Crashes	5	0.6%	45.5%	2	0.4%	22.2%
Near-Crashes	51	5.9%	63.0%	25	4.8%	41.0%
Crash-Relevant Conflict	802	93.5%	68.0%	498	94.9%	67.6%

Figure 2 illustrates the proportion of each SCE type where the subject driver was deemed to be at-fault. For each SCE type, a logistic regression model was used to determine if the probability of a crash being at-fault was different for older or younger drivers. The models were mixed-effect models and included a random error term for the subject driver. The odds of an at-fault near-crash for younger drivers were 2.4 times the odds for older drivers (near-crash odds ratio confidence interval [1.2, 5.6], $p = 0.0199$). The odds of an at-fault crash or crash-relevant conflict were not significantly different for younger and older drivers (crash odds ratio confidence interval [0.4, 21.8], $p = 0.3130$; crash-relevant conflict odds ratio confidence interval [0.5, 1.1], $p = 0.1690$). The small number of crashes likely contributed to the odds ratio not being found significantly different from 1.

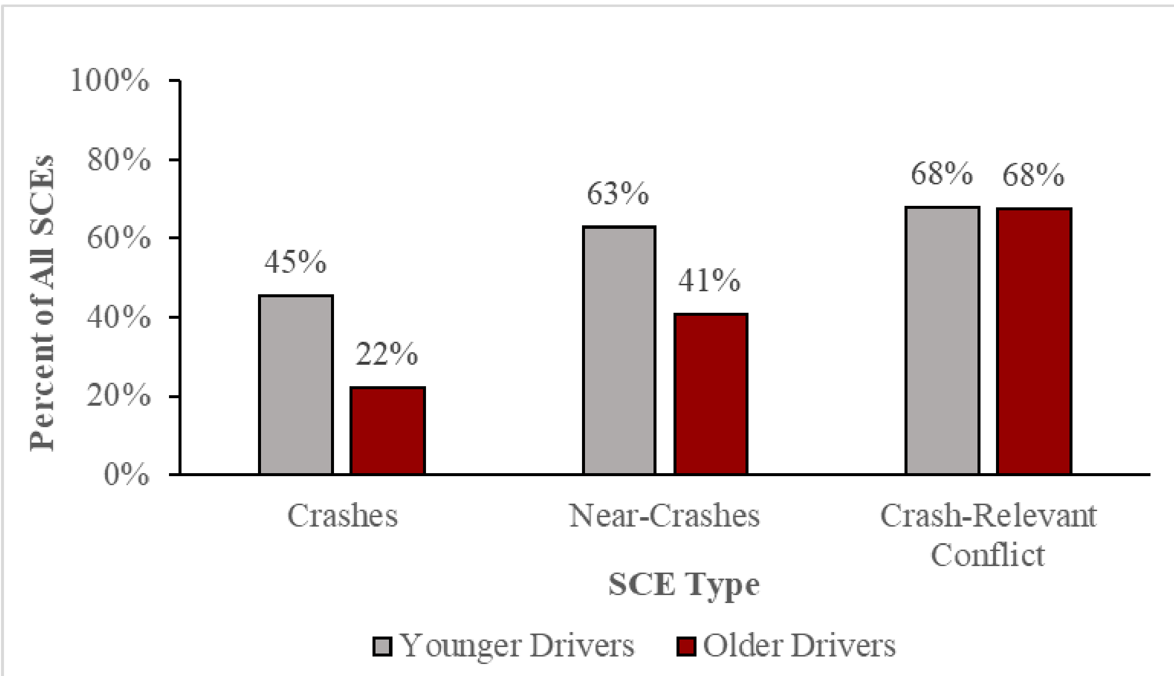

Figure 2. Bar graph. Proportion of at-fault SCEs by driver group and SCE type.

Table 3. Average SCE rate per 1,000 VMT for younger and older drivers by SCE type.

SCE Type	Younger Drivers Mean Rate (SD)	Older Drivers Mean Rate (SD)
All SCEs	1.628 (2.994)	1.369 (1.951)
At-Fault	1.109 (1.992)	0.991 (1.669)
Crash	0.015 (0.088)	0.045 (0.198)
Near-Crash	0.094 (0.270)	0.081 (0.204)
Crash-Relevant Conflict	1.519 (2.712)	1.244 (1.781)

The total number of miles driven by each CMV driver during the time he/she was participating in the aforementioned ND studies was calculated; CMV drivers in the older driver group accumulated 1.436 million miles, while the younger driver group amassed a total of 1.424 million miles. These data allowed for the calculation of SCE rates per 1,000 VMT (see Table 3). The average rate of SCEs per 1,000 VMT for the younger driver group was 1.628 compared to 1.369 for the older driver group. The two driver groups were compared for differences in SCE rate per 1,000 VMT using a negative binomial model with log link function. Mileage was included as an exposure variable by using the natural log of mileage as an offset. As shown in Table 4 and Table 5, the model indicated that the two age groups did not significantly differ in their SCE rate estimates at $\alpha = 0.05$.

Table 4. Maximum likelihood parameter estimate results for negative binomial model comparing all SCE rates per 1,000 VMT for younger and older driver groups.

Parameter	Parameter Level	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	*p*-value
Intercept		1	0.4241	0.1406	0.1486	0.6995	9.10	0.0026
Group	**Older**	1	-0.1797	0.2049	-0.5814	0.2220	0.77	0.3806
Group	**Younger**	0	0.0000	0.0000	0.0000	0.0000	.	.
Dispersion		1	1.2717	0.1432	1.0199	1.5858		

Table 5. Contrast estimate results for all SCE rates per 1,000 VMT for older versus younger driver groups.

Group Rate Ratio Comparison	Rate Ratio Mean Estimate	Rate Ratio Mean 95% Confidence Interval	Chi-Square	*p*-value
Older vs. Younger	0.8355	[0.5591, 1.2486]	0.77	0.3806

The average rate of at-fault SCEs per 1,000 VMT for the younger age group was 1.109 compared to 0.991 for the older driver group. The two driver groups were compared for differences in at-fault SCE rate per 1,000 VMT using a negative binomial model with log link function. Mileage was included as an exposure variable by using the natural log of mileage as an offset. As Table 6 and Table 7 show, the model indicated that the two age groups did not significantly differ in their at-fault SCE rate estimates at $\alpha = 0.05$.

Table 6. Maximum likelihood parameter estimate results for negative binomial model comparing at-fault SCE rate per 1,000 VMT for younger and older driver groups.

Parameter	Parameter Level	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	*p*-value
Intercept		1	0.0570	0.1705	-0.2772	0.3912	0.11	0.7383
Group	**Older**	1	-0.1185	0.2486	-0.6058	0.3687	0.23	0.6335
Group	**Younger**	0	0.0000	0.0000	0.0000	0.0000	.	.
Dispersion		1	1.9000	0.2183	1.5169	2.3798		

Table 7. Contrast estimate results for at-fault SCE rate per 1,000 VMT for older versus younger driver groups.

Group Rate Ratio Comparison	Rate Ratio Mean Estimate	Rate Ratio Mean 95% Confidence Interval	Chi-Square	*p*-value
Older vs. Younger	0.8882	[0.5456, 1.4459]	0.23	0.6335

The average rate of crashes per 1,000 VMT for the younger driver group was 0.015 compared to 0.045 for the older driver group. The two age groups were compared for differences in crash rate per 1,000 VMT using a negative binomial model with log link function. Mileage was included as an exposure variable by using the natural log of mileage as an offset. As Table 8 and Table 9 show, the model indicated that the two age groups did not significantly differ in their crash rate estimates at $\alpha = 0.05$.

Table 8. Maximum likelihood parameter estimate results for negative binomial model comparing crash rate per 1,000 VMT for younger and older driver groups.

Parameter	Parameter Level	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	*p*-value
Intercept		1	-4.8583	0.4167	-5.6751	-4.0415	135.90	<.0001
Group	**Older**	1	0.3134	0.6631	-0.9862	1.6131	0.22	0.6364
Group	**Younger**	0	0.0000	0.0000	0.0000	0.0000	.	.
Dispersion		1	4.6092	2.9430	1.3187	16.1110		

Table 9. Contrast estimate results for crash rate per 1,000 VMT for older versus younger driver groups.

Group Rate Ratio Comparison	Rate Ratio Mean Estimate	Rate Ratio Mean 95% Confidence Interval	Chi-Square	*p*-value
Older vs. Younger	1.3681	[0.3730, 5.0183]	0.22	0.6364

The average rate of near-crashes per 1,000 VMT for the younger driver group was 0.094 compared to 0.081 for the older driver group. The two driver groups were compared for differences in near-crash rate per 1,000 VMT using a negative binomial model with log link function. Mileage was included as an exposure variable by using the natural log of mileage as an offset. As Table 10 and Table 11 show, the model indicated that the two age groups did not significantly differ in their near-crash rate estimates at $\alpha = 0.05$.

Table 10. Maximum likelihood parameter estimate results for negative binomial model comparing near-crash rate per 1,000 VMT for younger and older driver groups.

Parameter	Parameter Level	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	*p*-value
Intercept		1	-2.8030	0.1616	-3.1197	-2.4862	300.84	<.0001
Group	**Older**	1	-0.1950	0.2462	-0.6776	0.2875	0.63	0.4282
Group	**Younger**	0	0.0000	0.0000	0.0000	0.0000	.	.
Dispersion		1	0.7518	0.2543	0.3874	1.4589		

Table 11. Contrast estimate results for near-crash rate per 1,000 VMT for older versus younger driver groups.

Group Rate Ratio Comparison	Rate Ratio Mean Estimate	Rate Ratio Mean 95% Confidence Interval	Chi-Square	*p*-value
Older vs. Younger	0.8228	[0.5078, 1.3331]	0.63	0.4282

The average rate of crash-relevant conflicts per 1,000 VMT for the younger driver group was 1.519 compared to 1.244 for the older driver group. The two driver groups were compared for differences in crash-relevant conflict rate per 1,000 VMT using a negative binomial model with log link function. Mileage was included as an exposure variable by using the natural log of mileage as an offset. As Table 12 and Table 13 show, the model indicated that the two driver groups did not significantly differ in their crash-relevant conflict rate estimates at $\alpha = 0.05$.

Table 12. Maximum likelihood parameter estimate results for negative binomial model comparing crash-relevant conflict rate per 1,000 VMT for younger and older driver groups.

Parameter	Parameter Level	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	*p*-value
Intercept		1	0.3567	0.1440	0.0744	0.6390	6.13	0.0133
Group	**Older**	1	-0.1987	0.2098	-0.6100	0.2126	0.90	0.3437
Group	**Younger**	0	0.0000	0.0000	0.0000	0.0000	.	.
Dispersion		1	1.3365	0.1513	1.0706	1.6684		

Table 13. Contrast estimate results for crash-relevant conflict rate per 1,000 VMT for older versus younger driver groups.

Group Rate Ratio Comparison	Rate Ratio Mean Estimate	Rate Ratio Mean 95% Confidence Interval	Chi-Square	*p*-value
Older vs. Younger	0.8198	[0.5434, 1.2368]	0.90	0.3437

PART II: YOUNGER VERSUS OLDER VERSUS OLDEST DRIVERS

In order to get a better understanding of the drivers aged 65 years and over, the "older drivers" group was subdivided into two age groups: older (50–64 years) and oldest (65+ years). Table 14 below includes summary statistics related to age, CMV driving experience, and mileage for each of the three driver groups. As can be seen in Table 14, the older group now included 59 drivers and the oldest group comprised only 6 drivers.

Table 14. Average age, CMV driving experience, mileage per driver, and total mileage for younger, older, and oldest drivers.

Driver Group	Count	Age (SD)	Age Range [min, max]	Yrs of Exp (SD)	Range of Exp [min, max]	Mileage per Driver (SD)	Total Mileage
Younger (30–40 years)	71	35.52 (2.94)	[30, 40]	7.88 (5.57)	[0.17, 21.00]	20,065.10 (12,299.61)	1,424,621
Older (50–64 years)	59	54.48 (3.60)	[50, 63]	16.74 (10.62)	[0.08, 43.00]	23,312.67 (24,703.95)	1,375,447
Oldest (65+ years)	6	70.33 (3.08)	[65, 73]	25.06 (21.54)	[5.00, 54.00]	10,249.00 (3,150.31)	61,494

The summary statistics in Table 14 illustrate how much different the oldest drivers were in terms of driving experience and mileage (i.e., per driver and total) compared to the younger and older groups. The boxplot below (Figure 3) displays the driving experience of all three age groups' distributions by minimum value at the lower whisker, first quartile in grey, median as the dividing line between grey and maroon, third quartile in maroon, and maximum value in upper whisker. The median experience for the two older driver groups was fairly similar (older drivers [50–64 years] and oldest drivers [65+ years] had median years of experience of 16 years and 18.13 years, respectively). However, the interquartile range was much larger for the oldest driver group. However, the sample size for this group is quite small, so the sample may not accurately describe the whole of the population. A non-parametric, Kruskal-Wallis test identified significant differences in CMV driving experience between the three groups of drivers ($\alpha = 0.05$, $\chi^2 = 26.62$, $p < 0.0001$).

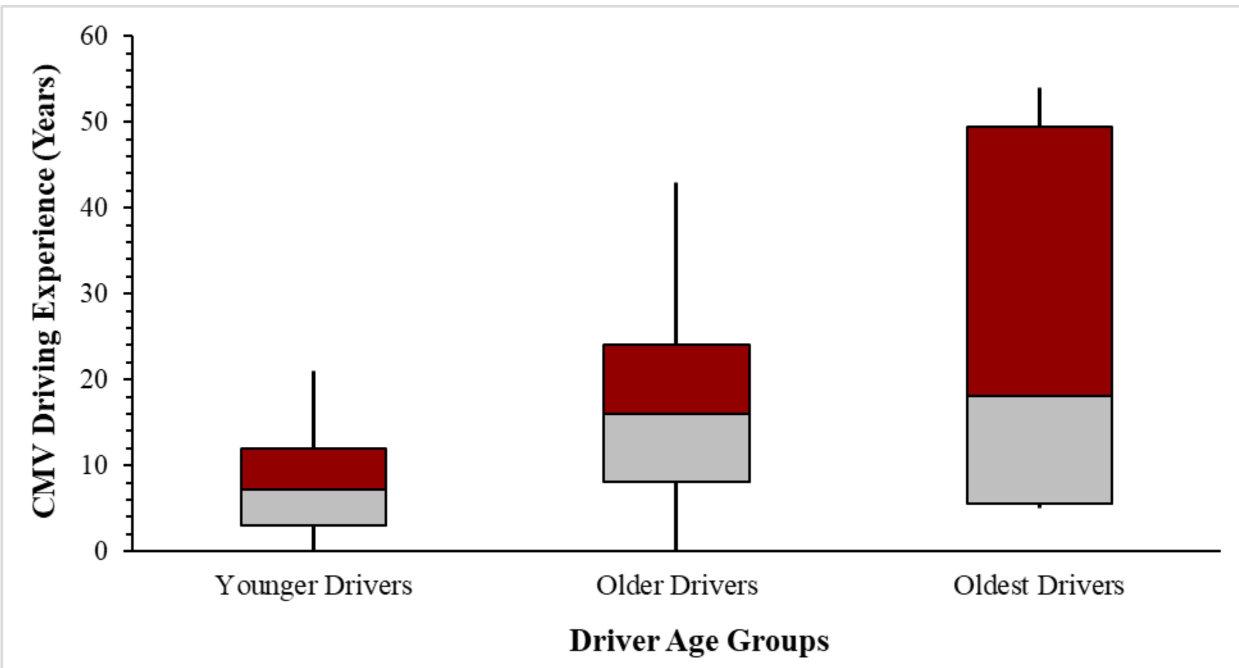

Figure 3. Boxplot. Median, quartiles, and minimum and maximum values of CMV driving experience in years for younger, older, and oldest driver age groups.

Driver mileage was calculated to determine SCE rates. As can be seen in Table 14, the average mileage for the oldest drivers (65+ years) was approximately half the mileage of the younger drivers (30–40 years) and older drivers (50–64 years). Tests to assess significant differences in mileage were not found to be statistically significant, despite the large difference in average mileage in each group. This is likely due to sample size of the oldest driver age group and the large spread of data for the younger and older driver groups.

Table 15. Distribution of SCEs in the younger, older, and oldest driver age groups.

SCE Type	Younger Drivers		Older Drivers		Oldest Drivers	
	SCE Count	Proportion of All SCEs	SCE Count	Proportion of All SCEs	SCE Count	Proportion of All SCEs
Crashes	11	0.9%	9	1.2%	0	0.0%
Near-Crashes	81	6.4%	60	8.3%	1	1.3%
Crash-Relevant Conflicts	1,180	92.7%	658	90.5%	79	98.7%
Total	1,272	100.0%	727	100.0%	80	100.0%

The distribution of the SCE types in the three age groups is described in Table 15 above. The younger driver group had a total of 1,272 SCEs, while the older driver group had a total of 727 SCEs and the oldest driver group had a total of 80 SCEs. Over 90% of SCEs for all groups were crash-relevant conflicts. Interestingly, the oldest driver group had no crashes and only one near-crash; however, as with previous results, this is likely due to the small number of drivers in the oldest group.

Table 16. Average SCE rates per 1,000 VMT for younger, older, & oldest driver age groups by SCE type

SCE Type	Younger Drivers Mean Rate (SD)	Older Drivers Mean Rate (SD)	Oldest Drivers Mean Rate (SD)
All SCEs	1.62 (2.99)	1.36 (2.03)	1.44 (1.03)
At-Fault	1.11 (1.99)	0.96 (1.72)	1.34 (1.06)
Crash	0.01 (0.09)	0.05 (0.21)	0.00
Near-Crash	0.09 (0.27)	0.09 (0.21)	0.03 (0.08)
Crash-Relevant Conflict	1.52 (2.71)	1.23 (1.85)	1.40 (1.01)

Table 16 shows the average rates per 1,000 miles for each SCE type. For all SCEs combined, the younger driver group had the highest rate of 1.62 SCEs per 1,000 miles, followed by the oldest driver group (1.44) and the older driver group (1.36). For at-fault SCEs, the oldest drivers had the highest rate of 1.34 at-fault SCEs per 1,000 miles, followed by the younger drivers (1.11) and older drivers (0.96). Average crash rate was 0.01 and 0.05 crashes per 1,000 miles for younger drivers and older drivers, respectively. Average near-crash rate was lowest for the oldest driver group (0.03 near-crashes per 1,000 miles), with rates of 0.09 for both younger and older drivers. Average crash-relevant conflict rate was highest for younger drivers at 1.52 crash-relevant conflicts per 1,000 miles, followed by the oldest drivers (1.40) then the older driver group (1.23). Non-parametric Kruskal-Wallis tests, comparing rates for each of the SCE categories, identified no statistically significant differences between age groups. The same conclusions were found in regression models of the data.

CHAPTER 4. DISCUSSION

The results clearly indicate that the older CMV driver group did not differ significantly from the younger CMV driver group in the vast majority of the comparisons made in Part I of the analyses. Interestingly, it was the younger driver group that was shown to have 2.4 times the odds of an at-fault near-crash compared to older drivers. An at-fault SCE is an indication that the subject driver caused the SCE in some way, and thus may be a reflection of driving behavior (e.g., aggressive or careless driving). This seems to suggest that older CMV drivers are more careful, or possibly more patient, than their younger counterparts, resulting in their reduced likelihood of being the cause of a near-crash.

One of the strengths of this study was that the ND data allowed for the calculation of total miles driven for each participant, which in turn facilitated the calculation of crash, near-crash, and crash-relevant conflict rates per 1,000 VMT. Comparing the driver groups based on SCE frequency (i.e., the number of SCEs the driver was involved in during the study) can be misleading if one group drove significantly more miles than the other group. Obviously, the more frequently or longer a person drives, the greater their exposure to a larger number of other vehicles and situations that may result in an SCE. Exposure data, such as VMT, allows for a true calculation of which group is more likely to be involved in an SCE.

Interestingly, Part II of the analysis in which the oldest drivers (i.e., 65+ years of age) were separated out into a group of their own, appeared to indicate that the oldest drivers only drove approximately half as many miles as the younger (30–40 years) and older (50–64 years) driver age groups. This difference in mileage for the oldest group of drivers would fit with the notion that older drivers may self-regulate their driving habits and patterns as they age, for example by driving fewer miles. However, despite the seemingly large differences in mileage, the results were not statistically significant, likely because of the small number of drivers in the oldest driver age group. The results also showed no difference in the miles driven between the younger (30–40 years) and older (50–64 years) driver groups. Given that these CMV drivers may not have had much say in how frequently they drove, this result is not entirely surprising. With regard to driving assignments, the older CMV drivers in this study seem to be held to the same standards and have the same expectations placed on them as their younger counterparts.

The SCE, at-fault SCE, crash, near-crash, and crash-relevant conflict rates did not differ significantly between the oldest, older, and younger driver groups. However, there were only a small number of crashes in the final data set, so the crash rate comparison needs to be interpreted with caution. The results provide overwhelming support for the notion that older (50–64 years) CMV drivers are just as safe behind the wheel of their CMVs as their younger counterparts. Unfortunately, there were too few drivers 65 years and over in this study to reach any firm conclusions about the oldest driver age group; however, this group was not responsible for an inordinately large number of SCEs considering there were only six drivers in the group. The breakdown of SCEs for the oldest driver group gave the impression they were just as safe as the other two groups, although this cannot be statistically tested or confirmed.

Not surprisingly, the oldest and the older driver group had significantly more CMV driving experience than the younger driver group. It stands to reason that older CMV drivers would, for the most part, have more driving experience, particularly if they have been working as a CMV driver for most of their adult life. What remains unclear is the impact driving experience, independent of age and vice versa (i.e., age independent of driving experience), has on CMV

SCE rates or crash risk. While it is highly likely that age and driving experience are interrelated, it is not possible to tease the two apart in the current study due to the relatively small number of drivers 65 years and over in the final data set. Thus, it is unknown if, and to what extent, driving experience mitigates the age-related declines that occur in the perceptual, cognitive, and psychomotor performance that are relevant to driving.

Regardless of these findings, there is growing support within the trucking industry for older drivers to be kept on the road. A *Transport Topics* article from 2014 outlines the multitude of benefits to retaining older experienced drivers, as long as they are in good health and pass their physical. Older drivers understand how freight moves across the country, they make efficient use of their time, can be trusted to work unsupervised, and often have impressive safety records. If a driver has been with the same company for decades, their dedication to their job and their customers is unquestionable. From a safety standpoint, older drivers tend to be more careful about how they work, as they are more aware of the limitations of their bodies. From a driving perspective, they tend to be more patient behind the wheel. Many older experienced drivers are asked to conduct training and demonstrations, as they understand the dangers and have an abundance of knowledge to be shared. Some carriers also pair new drivers with experienced drivers to serve as a mentor.(15) Clearly, not all older experienced CMV drivers fit this description. Rather, these are the drivers who choose to stay behind the wheel well after retirement age, into their 70s and even 80s, because they love their job, they are still able to drive their CMV safely, and the company they work for is willing to accommodate them by letting them work a shorter week, for example. However, the demands of the job and the age-related declines in driving performance are both well documented, and thus, if one or the other (or both) are not ideally suited to the driver in question, then it may not be beneficial to keep that driver on the road.

Unfortunately, the final data set limited the analyses and outcomes in a number of ways. The small number of drivers 65 years and over restricted the analysis and conclusions that could be made regarding this oldest group; however, the older (50–64 years) driver group were no more or less risky on the road than the younger (30–40 years) driver group. Thus, in terms of “aging” CMV drivers, these results are promising as there is no difference between the SCE rates of the two groups as the drivers age. More data from drivers 65 years and over is needed to investigate at what age CMV driver performance starts to deteriorate. While this study provided the means to conduct a preliminary investigation, a much larger data set including a larger population of drivers over the age of 65 years is needed to fully investigate the issue of aging CMV drivers’ SCE risk.

CHAPTER 5. REFERENCES

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