The Association Between Cardiovascular Disease Risk Factors and Motor Vehicle Crashes Among Professional Truck Drivers

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Objective: This study assesses relationships between the Framingham cardiovascular disease risk (CVD risk) score and prevalence of US Department of Transportation (DOT)-reportable crashes in commercial motor vehicle (CMV) drivers, after controlling for potential confounders. **Methods:** Data were analyzed from CMV drivers ($N = 797$) in a large cross-sectional study. CVD risk was calculated for each driver. Adjusted odds ratios (ORs) and 95% confidence intervals (95% CIs) between CVD risk and DOT-reportable crashes were calculated. **Results:** Drivers in the two highest CVD risk groups had significantly higher likelihood of crash (OR = 2.08, 95% CI = 1.20 to 3.63 and OR = 1.99, 95% CI = 1.05 to 3.77, respectively) after adjusting for confounders. There was a significant trend of increasing prevalence of crashes with an increasing CVD risk score ($P = 0.0298$). **Conclusion:** Drivers with a high CVD risk had a higher likelihood of a crash after controlling for confounders.

Heart disease is the leading cause of death in the United States for both men and women, with around 610,000 deaths per year.[1] The National Health and Nutrition Examination Survey data showed that nearly 47% of adults had at least one risk factor for cardiovascular disease (CVD).[2] CVD risk factors vary across ethnic, socioeconomic, and/or occupational groups.[1] Truck drivers have been shown to have a particularly high prevalence of CVD risk factors.[3–7]

Drivers are required to have a Commercial Driver Medical Examination (CDME) in order to become a licensed commercial motor vehicle (CMV) driver. This CDME is valid for up to 24 months; however, a certificate can be given for less than 24 months when it is desirable to monitor a condition, such as hypertension.[8] Yet, CMV drivers have been shown to have poor overall health[3,6,7,9–12] and a higher prevalence of CVD risk factors,[3–7] particularly tobacco use, hypertension, and obesity, compared with the general population.[3–7] The poor health status of truck drivers is commonly attributed to both lifestyle and occupational factors that include diet, physical inactivity, and prolonged sitting.[4–6,11,12]

Currently, there are an estimated three million CMV drivers in the United States.[13] In 2012, there were 333,000 large trucks (large trucks defined as weighing more than 10,000 pounds) involved in motor vehicle crashes in the United States.[14] There were 104,000 people injured in crashes involving large trucks with 79,000 (76%) of those injured having been occupants of other vehicles or nonoccupants (pedestrians, cyclists, etc).[14] In addition to those injured, there were 3921 fatalities in crashes involving large trucks, with 3224 (83%) of these fatalities having been occupants of other vehicles or nonoccupants.[14]

In 2012, the FMCSA estimated a total cost estimate of $38 Billon for crashes involving large trucks that caused injuries, and a total of $40 Billon for fatal crashes.[15] Many factors have been cited as contributing causes to crashes such as speeding, distraction/inattention, and impairment.[16] In a 1989 study conducted by the National Transportation Safety Board, 189 fatal truck accidents were analyzed. Ten percent of the accidents were attributed to medical problems, and of these 10%, 90% were classified as cardiovascular-related.[17] Other studies have shown that CVD has been associated with an increased crash risk among private drivers.[18–21] Therefore, an understanding of the relationship between a driver's CVD risk factors and crashes is warranted.

CVD risk factors can be quantified using various risk scores and risk calculators. The Framingham Risk Score has been used to assess and predict a person's individual risk for developing CVD over the next 10 years.[22] The scale provides a way to effectively quantify CVD risk.[23] The Framingham Risk Score is composed of blood pressure, total cholesterol, high-density lipoprotein (HDL) cholesterol, smoking, age, and blood pressure medications.[22–24] This risk score has been shown to be effective in predicting the development of CVD.[23]

The goal of this assessment was to analyze the relationship between the CVD risk score and the prevalence of US Department of Transportation (DOT)-reportable crashes among CMV drivers, after controlling for potential confounding factors.

METHODS

Study Population and Design

This cross-sectional study was approved by the University of Utah (IRB #22252) and the University of Wisconsin-Milwaukee Institutional Review Boards (IRB #07.02.297). As a prior publication has detailed methods, abbreviated methods follow.[25]

Participants ($N = 858$) were required to be a commercial truck driver with a current U.S. commercial driver's license (CDL) at the time of study enrollment. Participants were enrolled from 2008 to 2011 at various truck stops and professional truck shows in Utah and Wisconsin, and at truck shows in Kentucky, Texas, Nevada, and Iowa. Informed consent was obtained from all participants. Demographic and health information are provided in Table 1.

After enrollment and consent, participants completed computer-based questionnaires. Research assistants provided assistance to participants if they had any questions or difficulties. The questionnaire gathered demographic information, history of reportable motor vehicle crashes, past medical history, physical activities, hobbies, psychosocial factors, and many other elements.

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Signed informed consent was obtained from each driver or from their legal guardian and the study protocol was reviewed and approved by the University of Utah Institutional Review Board (IRB #22252) and the University of Wisconsin–Milwaukee Institutional Review Board (IRB #07.02.297).

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TABLE 1. Demographics and Cardiovascular Disease Risk Factors

Variables	*N*	%
Gender*		
Male	685	85.9
Race		
White	687	86.2%
Black or African American	37	4.6%
Hispanic or Latino	49	6.1%
Other	21	2.6%
Decline to answer	3	0.4%
BMI		
Underweight (<18.5 kg/m^2)	5	0.63%
Normal (18.5–24.9 kg/m^2)	80	10.0%
Overweight (25–29.9 kg/m^2)	219	27.5%
Obese (30–30.9 kg/m^2)	379	47.6%
Morbidly obese (>40 kg/m^2)	114	14.3%
Smoke*		
Yes	395	49.6
Regular exercise		
Yes	460	57.7
Truck crash		
Yes	308	38.6
Diagnosed with high blood pressure*		
Yes	230	28.9
Alcohol		
Yes	469	58.9
Diabetes mellitus		
No	712	89.3

Variables	Mean	STD DEV
Age	47.2	10.5
BMI (kg/m^2)	32.9	7.5
Weight, kg	103.4	24.2
Waist circumference, cm	113.2	17.3
Total weekly physical activity, min	281	365.9
Diastolic blood pressure, mm Hg	84.3	10.7
Systolic blood pressure, mm Hg*	131.9	17.4
HDL, mg/dL*	36.6	14.1
Total cholesterol, mg/dL*	191.5	41.2
Hemoglobin A1c	5.0	1.2
Glucose, mg/dL	121.7	54.8
Average 10-year cardiovascular disease risk†	8.9	8.2

*Variable used to calculate Framingham 10-year Cardiovascular Risk.

†Average 10-year cardiovascular disease risk is an estimate of an individual's chance (%) for developing CVD within the next ten years. Average 10-year risk was calculated using the variables: systolic blood pressure, total cholesterol, HDL cholesterol, smoking, age, and gender.

Research assistants recorded driver's neck circumference, chest circumference, waist circumference, hip circumference, height, weight, and blood pressure. A finger-stick was analyzed, including total cholesterol, HDL cholesterol, low-density lipoprotein (LDL) cholesterol, and triglyceride levels.

The entire enrollment process took an average of 1 hour and all subjects were provided a $20 gift-card for participation. There was no follow-up with participants, as this study was of cross-sectional design.

Cardiovascular Risk Factor Exposures

The Framingham Heart Study was originally incepted in 1948.[22,24] From that cohort study, the Framingham Risk Scale has been developed[22–24] and was used to assess 10-year CVD risk among this study population. The risk factors assessed were age, gender, total cholesterol, HDL cholesterol, smoking, systolic blood pressure, and use of blood pressure medications. A detailed description of CVD risk calculation is provided in Table 2. Each risk variable (eg, total cholesterol) is assigned a point value on the basis of the value of the risk variable, and the age and gender of the participant. For example, a 45-year-old male who is a smoker with a total cholesterol level of 205 mg/dL, an HDL level of 43 mg/dL, and unmedicated systolic blood pressure of 135 mm Hg received 3 points for age, 5 points for total cholesterol, 5 points for smoking, 1 point for HDL, and 1 point for systolic blood pressure. The points are summed for a total score of 15 in this case, which translates to a 10-year CVD risk estimate of 20% for this participant.

The Framingham Risk Scale was used to quantify CVD risk for each driver in this study. Drivers were categorized into seven groups on the basis of the percentage risk for developing CVD within the next 10 years. Each group included close to 100 participants to ensure stable estimates for each group. The groups ranged from lowest risk (0%) to highest risk (21% to 30%) (Table 3).

Crash Outcomes Assessment

There was one question asked in the questionnaire that assessed truck crashes among the truck drivers. The question was: Have you ever had any reportable motor vehicle crashes? A DOT-reportable crash is one that involved a fatality, an injury requiring immediate treatment away from the scene, or any vehicle involved having to be towed due to disabling damage.[16]

Personal injury was not assessed as part of the questionnaire. However, near misses, number of crashes, and cause of each crash were each examined in the questionnaire.

Statistical Analysis

SAS 9.4 software (SAS Institute Inc., Cary, NC) was used for data analysis. Multivariate logistic regression analysis was used to analyze the relationship between CVD risk and DOT-reportable crash. Each CVD risk group [eg, high-risk group (21% to 30%)] was compared with the lowest risk group (0%) in order to assess the relationship between increased CVD risk and DOT-reportable crash.

The potential confounding factors such as age, gender, body mass index (BMI), cell phone use while driving in the city, depression, alcohol and drug use, physical exhaustion, professional driving time, sleep problems, sleep apnea, sitting time while not on the road, diabetes, and psychosocial factors were assessed. Only age, gender, BMI, and cell phone use while driving remained in the adjusted model because they showed a relationship with CVD risk and DOT-reportable accidents. Adjusted odds ratios (ORs) and confidence intervals (CIs) were used to assess statistical signficance at *P* value less than 0.05. Means and frequencies were used to describe the population.

RESULTS

Demographic Data

Complete data for 797 of the 858 drivers enrolled (92.9%) were available for analysis. Drivers were excluded from final analyses for the following reasons: missing or incomplete questionnaire data, inconsistencies in their responses in the questionnaire, and enrolling in the study twice at different locations. One complete data set was kept from duplicate participants.

Most drivers were male 685 (85.9%) (see Table 1), the mean age was 47.2 years, and 687 (86.2%) participants were Caucasian. Drivers had a mean BMI of 32.9 kg/m^2 and 507 (61.9%) were classified as obese (BMI $\geq$30 kg/m^2). Most drivers also reported drinking alcohol at least once in the past year, 569 (58.9%). Drivers reported weekly physical activity averaging 281 minutes and more than half of the drivers reported participating in regular exercise. However, 102 drivers (12.8%) reported no physical activity on a

TABLE 2. Point Values Given for the Various CVD Risk Factors According to the Framingham Scale

Framingham Score Calculation

For Men

		Total Cholesterol (mg/dL)				Smoking	HDL (mg/dL)				Systolic Blood Pressure (mm Hg)			
Age, yrs	Age Points	160–199	200–239	240–279	280+	Smoker	60+	50–59	40–49	<40	120–129	130–139	140–159	160+
20–34	−9	4	7	9	11	8	-1	0	1	2	If untreated with medication			
35–39	−4										0	1	1	2
40–44	0	3	5	6	8	5								
45–49	3													
50–54	6	2	3	4	5	3								
55–59	8										If Treated with Medication			
60–64	10	1	1	2	3	1					1	2	2	3
65–69	11													
70–74	12	0	0	1	1	1								
75–79	13													

For Women

		Total Cholesterol (mg/dL)*				Smoking+	HDL (mg/dL)				Systolic Blood Pressure (mm Hg)†			
Age	Age Points	160–199	200–239	240–279	280+	Smoker	60+	50–59	40–49	<40	120–129	130–139	140–159	160+
20–34	−7	4	8	11	13	9	−1	0	1	2	If untreated with medication			
35–39	−3										1	2	3	4
40–44	0	3	6	8	10	7								
45–49	3													
50–54	6	2	4	5	7	4								
55–59	8										If treated with medication			
60–64	10	1	2	3	4	2					3	4	5	6

Scores for each individual risk factor (according to gender and age of the participant) were summed to give a total. The total score equated to a percentage used to quantify CVD risk.

*Total cholesterol <160 mg/dL has a 0 value for all age groups and both genders. +- Nonsmokers had a 0 value for all age groups and both genders.

†Systolic blood pressure <120 mm Hg has a 0 value for all age groups and both genders.

weekly basis. Drivers filled out information about their physical activity and participation in individual sports and activities. MET levels were derived using the information about the time and frequency a driver spent performing a certain activity (eg, swimming, running, walking). The mean MET level estimated from their recalled activities was 12.97 ± 23.6 mL/kg/min. Drivers also reported sitting on average 4.3 hours per day outside of work.

More than one-fourth of drivers (28.9%) had been told that they had high blood pressure by a physician. Of those diagnosed with high blood pressure, 76.9% reported taking medication to lower their blood pressure. About 26.7% of drivers reported having been diagnosed with high cholesterol and 50% of them were taking cholesterol-lowering medication. A total of 308 (38.6%) drivers reported having been in at least one DOT-reportable crash.

The Seven CVD Risk Categories

The average 10-year CVD risk percentage was 8.9% according to the Framingham Risk Scale. This variable was derived by

TABLE 3. Adjusted Odds Ratios and 95% Confidence Intervals for Being Involved in a Crash for the Seven Groups of Cardiovascular Disease Risks

Framingham 10-Year CVD Risk	*N* (%)	Number or Drivers Reporting Having Been in a DOT Crash (%)	Odds Ratio	95% Confidence Intervals	
Lowest risk (0%)	123 (15.4)	36 (29.3)	1.00	(Reference)	
1–2%	149 (18.7)	47 (31.5)	1.14	0.67	1.94
3–5%	107 (13.4)	43 (40.2)	1.58	0.90	2.78
6–8%	108 (13.6)	41 (38.0)	1.30	0.73	2.29
9–12%	120 (15.1)	48 (40.0)	1.45	0.83	2.54
13–20%	122 (15.3)	60 (49.2)	2.06*	1.18	3.60
Highest risk (21–30%)	68 (8.5)	33 (48.5)	2.00*	1.05	3.77

There was a significant trend in increased risk for crash across the CVD risk groups ($P = 0.0046$).

*$P < 0.05$ adjusted for gender, body mass index, and cell phone use while driving in the city.

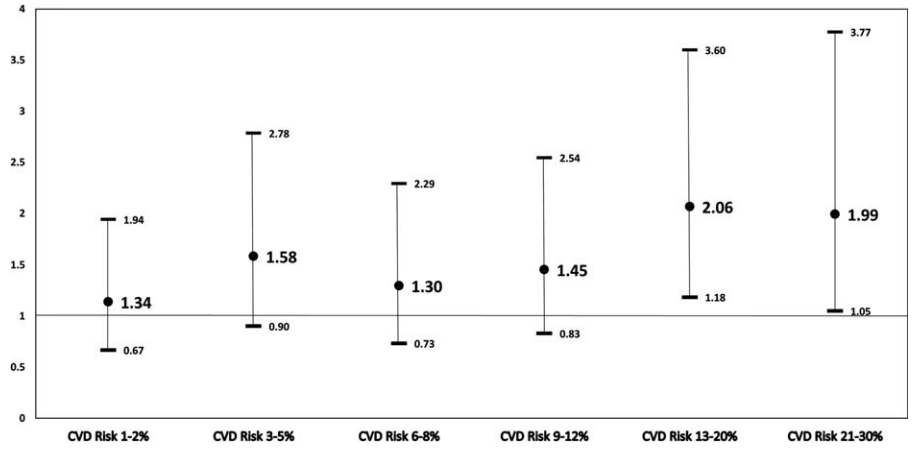

FIGURE 1. Cardiovascular disease (CVD) risk factor scores with odds ratios and 95% confidence intervals for DOT-reportable crash compared to the reference group (0% CVD risk).

adding up the total points for each individual CVD risk factor (see Table 2). The total CVD risk score correlates with an individual risk percentage according to the National Heart, Lung, and Blood Institute (NHLBI).[22] More than one-third of drivers (38.9%) had a CVD risk percentage of 9% or higher, and nearly 10% of drivers (8.5%) had a risk greater than 20%. Drivers with the highest risk for CVD (Framingham Score >20%) and those with the second highest risk (Framingham Score 16%–20%) were more likely have a reportable crash than the drivers with the lowest risk score (0%), OR = 2.00 (95% CI, 1.05 to 3.77) and OR = 2.06 (95% CI, 1.18 to 3.60), respectively (Table 3). There was a statistically significant trend of increasing prevalence of crashes with an increasing CVD risk score ($P = 0.0298$). Analyses of quartiles and tertiles demonstrated similar relationships but are not presented, as they were less informative. Figure 1 shows the ORs and 95% CIs for the seven CVD risk groups.

When drivers were divided up into risk categories on the basis of CVD risk [low risk (0% to 9%), moderate risk (10% to 20%), and high risk (>20%)], only the moderate risk group showed a significantly higher OR than the low-risk group for reportable crashes, OR = 1.40 (95% CI, 1.00 to 1.95). The high-risk group did not show a significant difference; however, the OR approached significance ($P = 0.08$), OR = 1.60 (95% CI, 0.95 to 2.71).

DISCUSSION

As the CVD risk estimate rose, truck drivers had up to a doubled risk of having been in a DOT-reportable accident. This increased accident risk puts CMV drivers, as well as pedestrians and other drivers at a greater risk for injury and death. Drivers showed an average 10-year CVD risk of 8.9% according to the Framingham Heart Scale, and more than one-third of the drivers (38.9%) had a CVD risk of 9% or greater. Nearly 10% of drivers (8.5%) had a CVD risk percentage greater than 20%. Truck drivers also had a high prevalence of individual CVD risk factors such as low HDL levels that averaged 36 mg/dL, smoking among nearly half of the drivers, and more than half of the drivers (61.9%) were obese.

Many other factors have been found to be associated with crashes in truck drivers. In a recent analysis with the same cohort of drivers, all of the following were associated with an increased risk of crashes: increasing age, increasing truck driving experience, male sex, low back pain, heart disease, pulse pressure, cell phone use, feeling tense, and feeling physically exhausted after work.[25] Many of these factors are also related to CVD risk, including pulse pressure, increasing age, and male sex. Other studies have shown that truck drivers have an increased prevalence of hypertension, smoking, obesity, and diabetes.[3–7,9–12]

Although drivers have mandatory participation in CDMEs and licensing procedures, drivers continue to show high rates of CVD risk factors. In a large cohort of drivers ($N = 88,246$), it was found that the prevalence of obese (25.3% to 28.2%) and morbidly obese (22.2% to 31.1%) drivers increased from the year 2005 to 2012.[26] In addition, it was found that the prevalence of drivers with four or more health conditions increased from 0.5% to 2.3% and the number of drivers with three or more health conditions increased from 2.7% to 8.8%.[26] Thus, CMV drivers' health appears to be getting worse, despite the medical examination all drivers take at least every 24 months.

One reason for the elevated CVD risk factors and overall poor health of truck drivers could be that physical activity and exercise intensity may be lower in truck drivers than in other occupational groups.[27] Drivers in our study reported not meeting the minimum physical activity recommendations for adults of 150 minutes per week of moderate to vigorous exercise.[27] Drivers also reported sitting an average 4.3 hours per day while not on the road. Lack of moderate to vigorous physical activity on a regular basis along with excess sitting time (both occupationally and in leisure time) may have an adverse impact on drivers' cardiovascular health and of chronic diseases.[3,6,7]

There have been few interventional studies to address CVD risk factors in truck drivers,[12,28–30] many of whom are largely unable to participate in traditional health promotion programs due to occupational demands[12] of long haul driving. Interventional studies should be aimed at helping truck drivers improve their cardiovascular health. Successful, truck driver specific exercise and nutrition interventions may help drivers obtain more physical activity and proper nutrition while on the road.

To our knowledge, this is the first study to systematically evaluate CVD risk factors/scores and DOT-reportable crashes within CMV drivers. Strengths of the study include the large sample of CMV drivers and objective measurements of BMI, cholesterol, HDL cholesterol, and blood pressure. Weaknesses of this study include the usual limitations associated with a cross-sectional study. These include the potential for recall biases, although to produce this study's results, would require the bias or confounder to incrementally increase across the categories. Longitudinal studies are needed to confirm these results. Studies would also need to assess whether an improvement of CVD risk factors or overall cardiovascular health is associated with a decrease in crash frequency among CMV drivers over time.

CONCLUSION

Truck drivers with higher risks for CVD also have a greater risk of having been in motor vehicle crashes than drivers who were

at a lower risk for CVD. Cohort studies are needed to further evaluate the relationship between CVD risk and crashes in CMV drivers. The lifestyle and work environment of CMV drivers may contribute to these elevated CVD risk factors. The high prevalence of CVD risk factors among truck drivers may provide additional opportunities for crash prevention such as interventions aimed at improving drivers' health.

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