Factors Associated With Truck Crashes in a Large Cross Section of Commercial Motor Vehicle Drivers

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Objective: This large, cross-sectional study calculated prevalence of disorders and assessed factors associated with self-reported lifetime crashes. **Methods:** Truck drivers ($n = 797$) completed computerized questionnaires reporting crashes, demographics, psychosocial factors, and other elements, as well as had taken measurements (eg, height, weight, serum, and blood pressure). **Results:** Most drivers were male ($n = 685$, 85.9%), and the mean body mass index was 32.9 ± 7.5 kg/m^2 with 493 (61.9%) being obese. Many drivers ($n = 326$, 39.9%) experienced at least one, with 132 (16.6%) having multiple, lifetime, reportable crashes. Many factors were associated with crashes, including increasing age, increasing truck driving experience, male sex, alcohol, low back pain, heart disease, and feeling tense. The most consistent associations with crashes were pulse pressure, cell phone use, and feeling physically exhausted after work. **Conclusions:** Modifiable factors associated with self-reported crashes were identified. These suggest targeted interventions may reduce risks of crashes.

In general, commercial motor vehicle drivers, specifically truck drivers, sit for long times, have low levels of physical activity, have limited access to healthy food, are exposed to environmental hazards such as diesel particulate matter and whole body vibration (WBV), and may have high psychological stress. This occupational group is reported to have unusually poor health compared with other occupational groups. This poor health status has been attributed poor diets and lack of exercise and related to occupational, lifestyle and environmental factors that are unique to this occupation.[1–10] Few studies evaluate associations between these occupational, lifestyle and environmental factors and poor health outcomes such as cardiovascular disease, obesity, and obstructive sleep apnea. One survey at Tennessee truck stops reported an average body mass index (BMI) of 30 kg/m^2, with 37% overweight, 45% obese, and only 19% within normal weight ranges,[11] although it is unclear whether these data represent national findings. A national survey of US commercial long-haul truck drivers reported a BMI range of 17.2 to 61.7 kg/m^2, with substantially larger proportions who were obese (68.9%) and 17.4% were morbidly obese (BMI $\geq$40.0 kg/m^2).[12] Another recent study has reported high rates of obesity with significant relationships between obesity and other health conditions.[13]

Some data suggest that truck drivers have a greater prevalence of chronic diseases, particularly early heart disease, compared with either other employees in the same company or among the US male population.[4,14,15] An estimated 5% to 10% of truck drivers are initially denied certification pending results of additional clinical tests for medical conditions.[12,16–18] It is also estimated that one third of drivers are certified for less than 2 years due to medical reason(s).[18]

Transportation and utilities workers reportedly incur occupational morbidity, mortality, and cost burdens, which are disproportionate to their representation of approximately 4% of the US workforce. In 2009, the Federal Highway Administration reported that fatality and injury rates among large trucks and buses were 1.23 and 31.5 per billion miles traveled.[19] In 2010, 3261 fatal crashes involved large trucks, but the number of fatal crashes involving a combination of buses and large trucks was 3500. The Federal Motor Carrier Safety Administration reported data from three different reporting systems with approximately 286,000 large truck crashes, of which 2987 had at least one fatality and an additional 30,797 with at least one injury.[20] These data also revealed some differences in risks between these types of crashes.

We identified only five reports that evaluate the health status impacts on crash risks. One study reported that obese commercial truck drivers (BMI $\geq$30 kg/m^2) have an approximately doubled risk of crash.[1] Another study found many issues, including obesity and sex differences, related to nonfatal crashes among drivers.[21] The National Transportation Safety Board concluded that more than 30% of fatal truck crashes were due to fatigue, whereas 50% of reported drivers are obese, which is a risk for fatigue.[10] The Federal Motor Carrier Safety Administration's data also suggested that medical factors may play a role in at least 20% of crashes.[22] In addition, there has been an 11% increase in fatal crashes involving commercial trucks from 2009 to 2011.[23] Driver fatigue was reportedly the primary factor in the majority of these crashes. Nevertheless, the prevalence of health promotion–related risk factors including risks for fatigue, the relationships between and among them, and their impacts on truck drivers crashes have not been well studied.

The purpose of this study was to report the prevalence and relationships among potential occupational, lifestyle and environmental risk factors for self-reported crashes from a cross section of US truck drivers.

METHODS

Institutional Review Board approvals were obtained from the University of Utah (IRB#: 22252) and the University of Wisconsin–Milwaukee (IRB#: 07.02.297). All enrolled participants provided informed consent. This is a cross-sectional study of commercial truck drivers to measure health status indicators, chronic illness risk factors, and self-reported crash data.

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Drivers were recruited via direct contact at trucking shows, on-site at companies, truck stops, industry newsletters, and via the Internet (online) and flyers. Seven trucking shows were utilized for enrolling in six states (Illinois, Iowa, Kentucky, Texas, Nevada, and Utah). Three truck stops were utilized for enrollments in two states (Utah and Wisconsin). A total of 858 drivers were enrolled in the study, 26 (3.0%) were enrolled via (online) survey but excluded from final analyses, and 35 (4.1%) were excluded due to incomplete or missing survey data.

After consent was obtained, drivers completed a computerized, laptop-administered questionnaire with 864 items. Computerization was used to shorten administration time, improve quality control, including assuring data capture and inhibiting out of range answers. The questionnaire item domains included (1) demographics (eg, age, sex, and history of maximum body weight), (2) frequencies and durations of hobbies, physical activities, and outside of work activities, (3) medical history including diseases on the Commercial Driver Medical Examination (CDME) form such as diabetes mellitus, thyroid disorders, high blood pressure, high cholesterol, musculoskeletal disorders, inflammatory arthritis (including rheumatoid arthritis), and other relevant diseases, (4) psychosocial questions (eg, depression, job satisfaction, family problems, supervisory, and coworker support), (5) occupational specific questions (eg, miles driven, history of crashes, manual loading/unloading, and securing loads), and (6) other questions (eg, sleeping patterns, smoking, and alcohol consumption). Most of these items have been used elsewhere.[24,25]

Reportable crashes were self-reported in response to the question ''Have you ever had any reportable motor vehicle crashes as a professional driver?'' Snoring was self-reported in response to the question ''Do you snore at night?'' Sleep problems were self-reported for the question ''Have you ever been told by a physician that you have/had a sleep disorder, pauses in breathing while asleep, daytime sleepiness or loud snoring?''

Height and weight were measured in stocking feet using a stadiometer or digital scale in metric units to the nearest 10th of a centimeter and 10th of a kilogram, respectively. If the driver's body weight exceeded 300 lb, two scales are used simultaneously with the sum of the two scales recorded. These data were used to calculate BMIs.

Hip, waist, chest, and neck circumferences were recorded to the nearest half-centimeter with the participant standing. Waist circumference was measured at the smallest horizontal point between the 10th rib and the iliac crest. In some obese subjects, it may be difficult to identify a waist narrowing. In such cases, the smallest horizontal circumference was measured midway between the ribs and iliac crest. Hip circumference was measured horizontally at the level of maximum protrusion of the gluteal muscles. Chest circumference was measured under the arms.

Blood pressure and heart rate were obtained in a seated position after a minimum of 5 minutes of rest, and most often after 20 minutes of rest (after completing the questionnaire). Automated cuff measures were utilized (Omron HEM-780, Omron USA).

Drivers had their serum nonfasting total cholesterol, high-density lipoprotein cholesterol, triglycerides and hemoglobin A1c measured via fingerstick (Cholestech LDX and GDX machines, Alere Inc., Waltham, MA). The low-density lipoprotein cholesterol was calculated.[26]

Statistical Analyses

Statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC). Missing data were verified by pulling individual charts. Imputation using the population mean was used when missing data could not be verified. Less than 0.01% of data were imputed.

Descriptive statistics including means, medians, standard deviations, and frequencies were calculated for purposes of describing the population. Data were analyzed for normality and skewness. Continuous data were analyzed for both linear and nonlinear relationships by grouping continuous variables into commonly accepted categories (eg, BMI) and tertiles to maximize statistical power. Statistical significance was determined using α level of 0.05.

A test for trend was conducted for factors with three or more ordered categories. Continuous variables were also tested for nonlinear relationships with the crash outcome.

Variables were classified into personal and occupational factors and were analyzed separately. Univariate logistic regression analyses were performed to evaluate associations and calculate odds ratios (ORs) and corresponding 95% confidence intervals (95% CIs) between potential associated factors and self-reported lifetime crashes. Variables with meaningful evidence of association to the crash outcome ($P < 0.20$) or those that were clinically meaningful were considered for inclusion in multivariate models.

Multiple logistic modeling was performed using an epidemiological approach incorporating both statistical significance and clinical significance to create models for factors related to crashes. Colinearity between factors was assessed prior to multivariate model building to help ensure stability. Separate personal and occupational multivariate models were created and then combined into a comprehensive adjusted model.

RESULTS

A total of 858 truck drivers were enrolled, and 797 were included in these analyses (see Fig. 1 and Table 1). There were 685 (85.9%) males and 112 (14.1%) females. The mean age was 47.2 ± 10.5 years. The truck driving experiences were diverse with a mean 17.1 ± 11.8 years. Two thirds (66.6%) were long-haul drivers. A total of 311 (38.6%) drivers experienced at least one reportable crash in their lifetime, whereas 132 (16.6%) reported two or more crashes. Less than a quarter (23.5%) had jobs that required

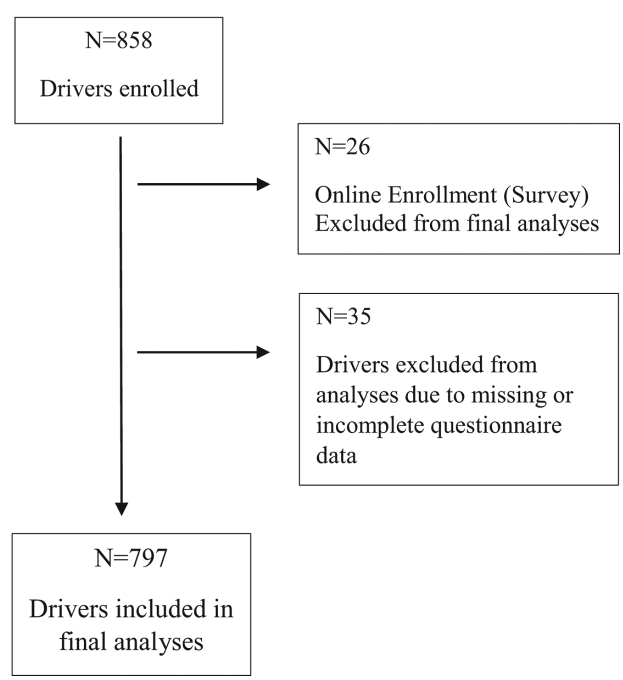

FIGURE 1. Flowchart of trucker data analyses. Note: Online enrollments were excluded from this study due to lack of objective measures needed for these analyses. Some drivers did not complete the enrollment processes for various reasons, usually lack of time.

TABLE 1. Descriptive Statistics of Occupational Factors Stratified by Lifetime Crash Prevalence ($n = 797$)

	Mean ± SD or *n* (%)	Lifetime Crash	
Occupational Factors	**Total**	**Yes ($n = 308$)**	**No ($n = 489$)**
Hours spent driving a truck per week	57.1 ± 19.6	57.8 ± 17.4	56.6 ± 20.8
Total work time at current company (yrs)*	7.3 ± 8.8	8.3 ± 9.4	6.7 ± 8.3
Total professional drive time (yrs)*	17.1 ± 11.8	20.8 ± 11.2	14.8 ± 11.5
Number of lifetime crashes			
0	489 (61.4)	—	489 (100.0)
1	176 (22.1)	176 (57.1)	—
2	79 (9.9)	79 (25.7)	—
3	36 (4.5)	36 (11.7)	—
4	7 (0.9)	7 (2.3)	—
5	6 (0.8)	6 (2.0)	—
6 or more	4 (0.5)	4 (1.3)	—
Health insurance**	468 (58.7)	198 (64.3)	270 (55.2)
Shift work***			
Day shift	288 (36.1)	115 (37.3)	173 (35.4)
Night shift	62 (7.8)	14 (4.6)	48 (9.8)
Swing shift	249 (31.2)	97 (31.5)	152 (31.1)
Variable shift	198 (24.8)	82 (26.6)	116 (23.7)
Haul type***			
Long haul	531 (66.6)	206 (66.9)	325 (66.5)
Short haul	227 (28.5)	83 (27.0)	144 (29.5)
Other	39 (4.9)	19 (6.2)	20 (4.0)
Physically exhausted after work***			
Never	120 (15.1)	35 (11.4)	85 (17.4)
Seldom	440 (55.2)	169 (54.9)	271 (55.4)
Often	178 (22.3)	79 (25.7)	99 (20.3)
Always	59 (7.4)	25 (8.1)	34 (7.0)
Mentally exhausted after work			
Never	157 (19.7)	61 (19.8)	96 (19.6)
Seldom	375 (47.1)	141 (45.8)	234 (47.9)
Often	210 (26.4)	77 (25.0)	133 (27.2)
Always	55 (6.9)	29 (9.4)	26 (5.32)
Feeling tense after work**			
Never	270 (33.9)	94 (30.5)	176 (36.0)
Seldom	380 (47.7)	146 (47.4)	234 (47.9)
Often	134 (16.8)	65 (21.1)	69 (14.1)
Always	13 (1.6)	3 (1.0)	10 (2.0)
Job requires them to work very hard physically			
Never	154 (19.3)	58 (18.8)	96 (19.6)
Seldom	408 (51.2)	152 (49.4)	256 (52.4)
Often	167 (21.0)	72 (23.4)	95 (19.4)
Always	68 (8.5)	26 (8.4)	42 (8.6)
Loading or unloading of the truck (lumping)	236 (29.6)	101 (32.8)	135 (27.6)
Job requires manual lifting	187 (23.5)	77 (25.0)	110 (22.5)

*$P < 0.01$; **$P < 0.05$; ***$P = 0.05$ to 0.10.
SD, standard deviation.

manual lifting. Slightly more than half of the participants reported having health insurance (58.7%). Nearly a third (29.7%) reported feeling physically exhausted after work. Few drivers also reported being mentally exhausted after work (33.2% "often" or "always") or feeling tense (18.4% "often" or "always").

Study participants had many unhealthy biometric measurements including BMI, blood pressure, and cholesterol (Table 2). The mean and median BMI were 32.9 kg/m^2 and 31.9 kg/m^2, respectively, with 493 (61.9%) of the drivers being obese (BMI $\geq$30 kg/m^2). Personal lifestyle variables include frequent tobacco use, an average of 4.7 hours of reported physical activity per week, and cell phone use in both cities and rural areas. A diagnosis of sleep apnea was relatively common (14.2%), and 50.4% report snoring at night. A history of low back pain in the past year was also common (31.1%), and 6.0% report having been diagnosed with heart problems.

Blood pressure measurements showed that (1) 58.7% met the CDME requirements of 140/90 or less mm Hg, (2) 35.8% for stage 1 (140 to 159/90 to 99 mm Hg), (3) 9.9% for stage 2 (160 to 179/100 to 109 mm Hg, and (4) 2.3% for stage 3 (greater than 180/110 mm Hg). One third (32.8%) of truck drivers with either systolic blood pressure of more than 160 mm Hg, or diastolic blood pressure of more than 95 mm Hg, or both are taking at least one medications for treatment. On the contrary, only 22.0% of drivers taking at least one blood pressure medication still have a measured systolic blood pressure of more than 160 mm Hg, or diastolic blood pressure of more than 95 mm Hg, or both (Fig. 2).

Thirteen participants did not give consent for having blood drawn or their cholesterol test resulted in an invalid result. More than one third ($n = 309$, 39.4%) of drivers with measured total cholesterol had a measured total cholesterol of more than 200 mg/dL. Two hundred twelve (26.7%) of truck drivers in this survey have been told by a physician that she or he had high cholesterol. One hundred six (13.3%) drivers have been told that they have high cholesterol and have a high measured cholesterol (Fig. 3).

TABLE 2. Descriptive Statistics of Personal Factors Stratified by Lifetime Crash Prevalence ($n = 797$)

Personal Factors	Mean ± SD or n (%) Total	Lifetime Reportable Crash Yes (n = 308)	No (n = 489)
Age (y)*	47.2 ± 10.5	48.9 ± 10.1	46.2 ± 10.6
Male Sex*	685 (85.9)	280 (90.9)	405 (82.8)
Body mass index	32.9 ± 7.5	33.1 ± 7.5	32.7 ± 7.4
Underweight (BMI <18.5 kg/m^2)	5 (0.6)	1 (0.3)	4 (0.8)
Normal (BMI = 18.5–24.9 kg/m^2)	80 (10.0)	30 (9.7)	50 (10.2)
Overweight (BMI = 25–29.9 kg/m^2)	219 (27.5)	79 (25.7)	140 (28.6)
Obese (BMI = 30–39.9 kg/m^2)	379 (47.6)	151 (49.0)	228 (46.6)
Morbidly obese (BMI ≥40 kg/m^2)	114 (14.3)	47 (15.3)	67 (13.7)
Waist circumference (in)	44.6 ± 6.8	44.8 ± 6.6	44.4 ± 6.9
Hip circumference (in)	45.1 ± 5.5	45.1 ± 5.6	45.1 ± 5.5
Neck circumference (in)	16.7 ± 1.8	16.8 ± 1.7	16.6 ± 1.8
Diagnosed with high blood pressure	230 (28.9)	98 (31.8)	132 (27.0)
Systolic blood pressure (mm Hg)	131.9 ± 17.4	133.2 ± 18.0	131.2 ± 16.9
Diastolic blood pressure (mm Hg)	84.3 ± 10.7	84.1 ± 10.8	84.4 ± 10.6
Hypertension CDME stages (mm Hg)			
Normal (≤140/90)	468 (58.7)	180 (58.4)	288 (58.9)
Stage 1 (140–159/90–99)	285 (35.8)	111 (36.0)	174 (35.6)
Stage 2 (160–179/100–109)	79 (9.9)	34 (11.0)	45 (9.2)
Stage 3 (>180/110)	18 (2.3)	6 (1.9)	12 (2.5)
Pulse pressure (mm Hg)*			
≤34	135 (16.9)	33 (10.7)	102 (20.9)
34–≤41	142 (17.8)	59 (19.2)	83 (17)
41–≤46	122 (15.3)	62 (20.1)	60 (12.3)
46–≤52	134 (16.8)	41 (13.3)	93 (19)
52–≤61	135 (16.9)	61 (19.8)	74 (15.1)
>61	129 (16.2)	52 (16.9)	77 (15.8)
Diagnosed with high cholesterol (>200 mg/dL)**	213 (26.7)	97 (31.5)	116 (23.7)
Total cholesterol (mg/dL) ($n = 785$)	191.5 ± 41.2	189.2 ± 39.2	192.9 ± 42.4
Total cholesterol (mg/dL) ($n = 785$)			
<200	488 (61.2)	197 (64.0)	291 (59.5)
≥200	309 (38.8)	111 (36.0)	198 (40.5)
LDL cholesterol (mg/dL) ($n = 645$)	112.7 ± 33.9	113.6 ± 33.2	112.1 ± 34.3
HDL cholesterol (mg/dL) ($n = 758$)	36.6 ± 14.1	35.8 ± 13.0	37.0 ± 14.8
Diagnosed with Diabetes Mellitus	85 (10.7)	39 (12.7)	46 (9.4)
Hemoglobin A1c (%) ($n = 770$)	5.0 ± 1.2	5.0 ± 1.2	5.0 ± 1.2
Total physical activity (hours per week)	4.7 ± 6.1	4.8 ± 6.4	4.6 ± 5.9
Education***			
8th grade or less	16 (2)	4 (1.3)	12 (2.5)
Some high school	76 (9.5)	35 (11.4)	41 (8.4)
High school graduate or GED	324 (40.7)	123 (39.9)	201 (41.1)
Some college	313 (39.3)	128 (41.6)	185 (37.8)
College graduate	68 (8.5)	18 (5.8)	50 (10.2)
Alcohol consumption (yes)**	469 (58.9)	195 (63.3)	274 (56.0)
Tobacco usage (yes)	395 (49.6)	153 (49.7)	242 (49.5)
Pack-years of cigarettes smoked	15.9 ± 27.1	19.0 ± 32.7	14.0 ± 22.7
Self-reported diagnosis of sleep apnea	113 (14.2)	47 (15.3)	66 (13.5)
Self-reported snoring at night**	402 (50.4)	172 (55.8)	230 (47.0)
Self-reported regular exercise	460 (57.7)	175 (56.8)	285 (58.3)
Self-reported heart problems**	48 (6.0)	26 (8.4)	22 (4.5)
Self-report low back pain in the past year**	248 (31.1)	109 (35.4)	139 (28.4)
Cell usage in the cities*			
Never (0 times)	207 (26.0)	54 (17.5)	153 (31.3)
Once a day	67 (8.4)	26 (8.4)	41 (8.4)
Once a week	45 (5.7)	21 (6.8)	24 (4.9)
More than once a day	312 (39.2)	137 (44.5)	175 (35.8)
Less than once a month	46 (5.8)	13 (4.2)	33 (6.8)
2–3 times a week	70 (8.8)	34 (11.0)	36 (7.4)
4–6 times a week	50 (6.3)	23 (7.5)	27 (5.5)
Cell usage in rural areas*			
Never (0 times)	151 (19)	39 (12.7)	112 (22.9)

TABLE 2. (*Continued*)

	Mean ± SD or *n* (%)	Lifetime Reportable Crash	
Personal Factors	**Total**	**Yes (*n* = 308)**	**No (*n* = 489)**
Less than once a month	25 (3.1)	7 (2.3)	18 (3.7)
Once a week	32 (4.0)	13 (4.2)	19 (3.9)
2–3 times a week	77 (9.7)	28 (9.1)	49 (10)
4–6 times a week	62 (7.8)	25 (8.1)	37 (7.6)
Once a day	68 (8.5)	25 (8.1)	43 (8.8)
More than once a day	382 (47.9)	171 (55.5)	211 (43.2)

*$P < 0.01$; ** $P < 0.05$; ***$P = 0.05$ to 0.10.

BMI, body mass index; CDME, Commercial Driver Medical Examination; GED, general education development; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SD, standard deviation.

Crude Odds Ratios Analyses

Univariate logistic regression analyses of occupational factors resulted in many meaningful and clinically significant relationships with lifetime crash prevalence (Table 3). Each year a driver worked for their current company and each decade a participant has been driving were both significantly related to lifetime prevalence of crashes. Participants who were driving at night were less likely to be report a crash in their lifetime.

Drivers who have health insurance were 1.5 times more likely to have been report a crash in their lifetime. Drivers who report often or always feeling physically exhausted after work were more likely to report a crash. Also, participants who reported often feeling tense were significantly more likely to have been report a crash. Other occupational factors, including always feeling mentally exhausted after work, loading or unloading their truck or mixed haul type, were not significantly related to reporting a crash.

Univariate logistic regression analyses demonstrated multiple significant relationships between reportable crashes and personal factors (Table 4). Age (OR = 1.29 per 10 years) and pulse pressure (OR range from 1.36 to 3.19 for different levels of increasing pulse pressure) were significantly associated with an increased risk for lifetime history of a reportable crashes. Personal factors of pack years tobacco use (OR = 1.07 per 10 pack years), alcohol use (OR = 1.35), cell use in cities (ORs ranged from 1.80 to 2.68 for categories of cell use frequency, many were statistically significant), and cell use in rural areas (ORs from 1.64 to 1.97, only four to six times a week was statistically significant) were also associated with increased risk for reporting a crash. Drivers with a past diagnosis of heart problems (OR = 1.96), snoring at night (OR = 1.42), and low back pain (OR = 1.38) had statistically increased odds of having reported a crash. Females were half as likely to report a crash (OR = 0.48) as compared to males.

Adjusted Odds Ratios

Three multivariate models, a personal model, an occupational model, and a combined model were created, adjusting for all other factors in each model (Table 5). Personal factors adjusted for in the personal multivariate model include age, sex, BMI, pulse pressure, alcohol consumption, low back pain in the past year, past diagnosis of heart problems, cell phone use in cities, and feeling tense. All of these variables remained significant except for BMI, although BMI is also likely colinear with some of them. Assessments of colinearity between BMI and these factors did not yield statistically significant results in pairwise analyses. The strongest colinear relationship was

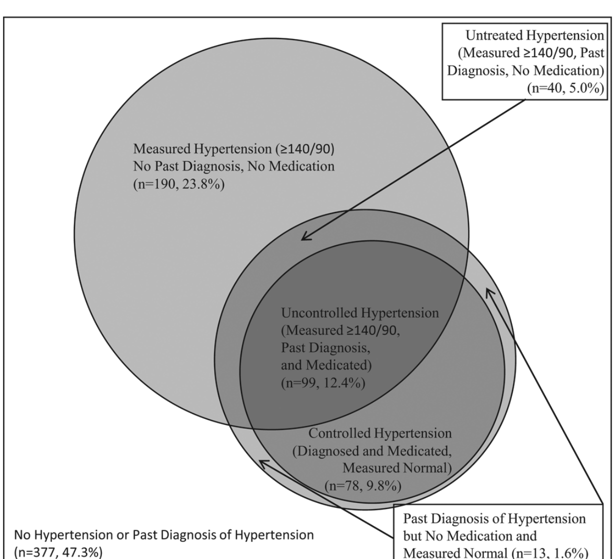

FIGURE 2. Proportionate Venn diagram of measured hypertension (systolic ≥140 mm Hg and/or diastolic ≥90 mm Hg), past diagnosis of hypertension, and medication for hypertension.

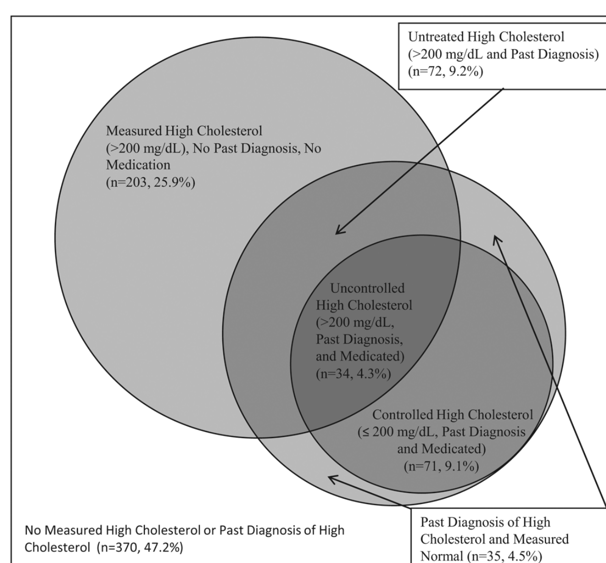

FIGURE 3. Proportionate Venn diagram of measured high cholesterol (more than 200 mg/dL) and history of high cholesterol (more than 200 mg/dL) and one or more medication for high cholesterol.

TABLE 3. Crude (Bivariate) Odds Ratios and 95% Confidence Intervals of Associations Between Occupational factors and Lifetime Crash Prevalence

Variable	Odds Ratio and 95% Confidence Interval
Hours spent driving a truck per week (per hour)	1.01 (1.00, 1.02)
Total work time at current company (per year)	1.02 (1.00, 1.04)*
Total professional drive time (per 10 yrs)	1.56 (1.38, 1.77)*
Health insurance: yes	1.46 (1.09, 1.96)*
Shift work	
Day shift	1.00 (reference)
Night shift	0.44 (0.23, 0.83)*
Swing shift	0.96 (0.68, 1.36)
Variable shift	1.06 (0.74, 1.54)
Haul type	
Long haul	1.00 (reference)
Short haul	0.91 (0.66, 1.25)
Other	1.50 (0.78, 2.88)
Physically exhausted after work*	
Never	1.00 (reference)
Seldom	1.51 (0.98, 2.35)
Often	1.94 (1.18, 3.17)*
Always	1.79 (0.93, 3.42)*
Mentally exhausted after work	
Never	1.00 (reference)
Seldom	0.95 (0.65, 1.39)
Often	0.91 (0.60, 1.40)
Always	1.76 (0.95, 3.26)
Job requires them to work very hard physically	
Never	1.00 (reference)
Seldom	0.98 (0.67, 1.44)
Often	1.25 (0.80, 1.96)
Always	1.03 (0.57, 1.84)
Loading or unloading truck (lumping)	1.28 (0.94, 1.74)
Job requires manual lifting	1.15 (0.82, 1.60)

*indicates statistical significance with $P < 0.05$.

between BMI and age but was not statistically significant ($P = 0.334$).

Occupational multivariate model included age, sex, BMI, time as a commercial motor vehicle driver, being mentally exhausted after work, and being physically exhausted after work. In contrast with the personal multivariate model, only driving experience and feeling physical exhausted after work were significantly associated with crash.

A combined personal and occupational factor multivariate model included all factors in each individual multivariate model. That model found that driving experience, feeling physically exhausted after work, and urban cell phone use were statistically significant, whereas low back pain in the past year and a history of heart problems were borderline significant.

DISCUSSION

Many personal and occupational variables differed significantly between drivers with and without at least one lifetime reportable crash. These include increased age, truck driving experience (total work time at current company and total professional drive time), male sex, pulse pressure, alcohol use, low back pain, heart disease, cell phone use, and feeling exhausted after work. Nevertheless, only pulse pressure, feeling exhausted after work, and urban cell phone use remained significant in the combined model. Most of these relationships have suggested biological plausibility and are similar to associations found in other studies.[27–29] These findings somewhat contrast with other reported associations, particularly with BMI and crashes,[10,30,31] although

TABLE 4. Crude Odds Ratios and 95% Confidence Intervals of Associations Between Personal Factors and Lifetime Crash Prevalence

	Odds Ratio
Age (per 10 yrs)	1.29 (1.12, 1.48)*
Sex Female	0.48 (0.31, 0.76)*
Body mass index (per kg/m^2)	1.01 (0.99, 1.03)
Underweight (BMI <18.5)	0.42 (0.04, 3.90)
Normal (BMI = 18.5–24.9)	1.00 (reference)
Overweight (BMI = 25–29.9)	0.94 (0.56, 1.56)
Obese (BMI ≥30)	1.10 (0.67, 1.82)
Morbidly obese (BMI ≥40)	1.17 (0.65, 2.10)
Waist circumference (in)	1.01 (0.99, 1.03)
Hip circumference (in)	1.01 (0.98, 1.03)
Neck circumference (in)	1.07 (0.98, 1.16)
Systolic blood pressure (mm Hg)	1.01 (1.00, 1.02)
Diastolic blood pressure (mm Hg)	1.00 (0.98, 1.01)
Pulse pressure (mm Hg)†	
≤34	1.00 (reference)
34–≤41	2.20 (1.31, 3.68)*
41–≤46	3.19 (1.88, 5.42)*
46–≤52	1.36 (0.80, 2.33)
52–≤61	2.55 (1.52, 4.28)*
>61	2.09 (1.23, 3.54)*
Total cholesterol (mg/dL)	1.00 (0.99, 1.00)
LDL cholesterol (mg/dL)	1.00 (1.00, 1.01)
HDL cholesterol (mg/dL)	0.99 (0.98, 1.00)
Hemoglobin A1c (%)	1.03 (0.92, 1.17)
Pack-years of cigarette use (per 10 pack-years)	1.07 (1.01, 1.13)*
Total physical activity (hours per week)	1.01 (0.98, 1.03)
Alcohol consumption	1.35 (1.01, 1.81)*
Self-reported diagnosis of heart problems	1.96 (1.09, 3.52)*
Self-reported sleep apnea diagnosis	1.15 (0.77, 1.73)
Self-reported snoring at night: yes	1.42 (1.07, 1.90)*
Low back pain last year	1.38 (1.02, 1.87)*
Cell usage in cities†	
Never (0 times)	1.00 (Reference)
Less than once a month	1.12 (0.55, 2.28)
Once a week	2.48 (1.28, 4.81)*
2–3 times a week	2.68 (1.53, 4.69)*
4–6 times a week	2.41(1.28, 4.56)*
Once a day	1.80 (1.01, 3.21)*
More than once a day	2.22 (1.51, 3.25)*
Cell usage in rural area†	
Never (0 times)	1.00 (Reference)
Less than once a month	1.12 (0.43, 2.88)
Once a week	1.97 (0.89, 4.35)
2–3 times a week	1.64 (0.91, 2.96)
4–6 times a week	1.94 (1.04, 3.62)*
Once a day	1.67 (0.90, 3.08)
More than once a day	2.33 (1.54, 3.53)*
Feeling tense	
Never	1.00 (reference)
Seldom	1.17 (0.84, 1.62)
Often	1.76 (1.16, 2.69)*
Always	0.56 (0.15, 2.09)

*$P < 0.05$.
†Test for trend with a P value <0.05.

BMI is also likely colinear with several of these variables. In addition, many of these factors are modifiable and suggest that there may be targeted interventions that would reduce crash risk among these drivers.

Obesity

Few data detail the factors associated with prevalence of obesity among truck drivers, but a sedentary work environment is

TABLE 5. Adjusted Odds Ratios and 95% Confidence Intervals for Factors Associated With Lifetime Crash Prevalence

	Adjusted Personal Factor Model	Adjusted Occupational Factor Model	Combined Personal and Occupational Factor Model
	Odds Ratio	Odds Ratio	Odds Ratio
Age (10 years)	1.28 (1.10, 1.50)*	1.02 (0.85, 1.23)	1.01 (0.83, 1.23)
Gender			
Male	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Female	0.52 (0.32, 0.85)*	0.67 (0.41, 1.08)	0.71 (0.42, 1.20)
Body mass index (per kg/m^2)	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)
Pulse Pressure (mm Hg)			
≤34	1.00 (Reference)		1.00 (Reference)
>34–41	1.91 (1.10, 3.29)*		1.99 (1.14, 3.50)*
>41–46	2.49 (1.42, 4.36)*		2.84 (1.59, 5.06)*
>46–52	1.09 (0.61, 1.95)		1.14 (0.63. 2.08)
>52–61	2.17 (1.25, 3.77)*		2.36 (1.34, 4.17)*
>61	1.69 (0.96, 2.97)		1.71 (0.96, 3.05)
Alcohol Consumption	1.42 (1.03, 1.95)*		1.44 (1.04, 1.99)*
Low Back Pain Last Year	1.44 (1.03, 2.02)*		1.32 (0.93, 1.99)
Diagnosis of Heart Problems	2.06 (1.10, 3.86)*		1.86 (0.96, 3.58)
Cell usage in Cities			
Never (0 times)	1.00 (Reference)		1.00 (Reference)
Less than once a month	1.34 (0.63, 2.83)		1.42 (0.65, 3.08)
Once a week	2.73 (1.34, 5.54)*		2.67 (1.28, 5.55)*
2–3 times a week	2.49 (1.37, 4.55)*		2.58 (1.39, 4.80)*
4–6 times a week	2.45 (1.24, 4.83)*		2.35 (1.17, 4.71)*
Once a day	1.63 (0.88, 3.01)		1.44 (0.76, 2.73)
More than once a day	2.09 (1.39, 3.15)*		1.81 (1.19, 2.77)*
Feeling Tense after work			
Never	1.00 (Reference)		1.00 (Reference)
Seldom	1.05 (0.74, 1.49)		1.07 (0.74, 1.54)
Often	1.69 (1.07, 2.68)*		1.67 (0.99, 2.73)
Always	0.40 (0.10, 1.57)		0.33 (0.08, 1.48)
Total Professional Drive Time (per 10 years)		1.52 (1.29, 1.79)*	1.52 (1.27, 1.80)*
Mentally exhausted after work			
Never		1.00 (Reference)	1.00 (Reference)
Seldom		0.79 (0.51, 1.23)	0.70 (0.44, 1.12)
Often		0.80 (0.49, 1.31)	0.60 (0.35, 1.03)
Always		1.84 (0.88, 3.87)	1.49 (0.68, 3.27)
Physically exhausted after work			
Never		1.00 (Reference)	1.00 (Reference)
Seldom		1.95 (1.18, 3.24)*	1.68 (0.99, 2.85)
Often		2.59 (1.45, 4.63)*	2.20 (1.20, 4.07)*
Always		1.47 (0.68, 3.20)	1.25 (0.55, 2.84)

likely a major contributor to obesity in this population. Truck drivers spend prolonged amounts of time sitting while they are working, and obesity has been significantly associated with prolonged sitting time[32] with the risk for being overweight or obese almost doubling (OR = 1.92, 95% CI, 1.17 to 3.17) among men who sat for more than 6 hours per day, as compared to those who sat for 45 minutes or less. Furthermore, among the general working population, obese workers are more than twice as likely to have work limitations as compared to normal weight workers.[33]

This study found a rate of obesity in truck drivers (62%) that was fairly comparable to another study's national estimate of 69%.[12] This study data did not find an independent statistical association between BMI category and reported history of a crash, although the small minority that was either underweight or normal weight (10.6%) may have resulted in an unusual underpowering of this study's data. Variables that were significant included variables likely colinear with obesity including pulse pressure and feeling exhausted.

Hypertension

Previously published estimates of hypertension among truck drivers range from approximately 23%,[2] to 40%,[11] with differences likely stemming from using blood pressure measurements or self-reported data. This study was comparable with 28.9%, reporting having been told by a physician to have high blood pressure. Nevertheless, 190 (23.8%) truck drivers in this survey have not been told that she or he had high blood pressure but had blood pressure measurements (greater than 140/90 mm Hg). This study also found that (1) 58.7% met the CDME requirements of 140/90 or less, (2) 35.8% for stage 1 (140 to 159/90 to 99), (3) 9.9% for stage 2 (160 to 179/100 to 109), and (4) 2.3% for stage 3 (greater than 180/110). Hertz et al[33] found that only 13% of truck drivers with either systolic blood pressure of more than 160 mm Hg, or diastolic blood pressure of more than 95 mm Hg, or both were taking medication for hypertension. In comparison, results of our survey showed that 32.8% of truck drivers with either systolic blood pressure of more than 160 mm Hg, or diastolic blood pressure of more than 95 mm Hg, or both are taking at least one medication for treatment. This suggests that undertreated and untreated hypertension may be common in this population. This study also found that pulse pressure is significantly associated with crashes.

High Cholesterol

A survey of US long-haul truck driver health reported 21.7% of drivers have high cholesterol.[12] This is markedly lower than the

39.4% with measured total cholesterol of more than 200 mg/dL in this study. Ultimately, difference in self-reported prevalence of high cholesterol as compared to measured high cholesterol could be attributed to undiagnosed hypercholesterolemia.

Cardiovascular Disease

A history of heart disease was nearly significantly associated with reportable crashes despite being underpowered. As there is also a relationship with pulse pressure, this raises issues regarding whether better cardiovascular disease risk factor management may reduce crash risks. This suggests that cardiovascular disorders may be independent risk factors for crash, which would have to be definitively determined on the basis of prospective studies.

Low Back Pain

Back pain that has lasted longer than 1 day was significantly associated with an increased risk for reportable crashes. Having back pain may provide a distraction for drivers, and it may provide limitations in ranges of motion to adequately drive. A prior report also found that commercial truck drivers are at increased risk for low back pain.[18] In a comprehensive review in 1997 by National Institute for Occupational Safety and Health (Cincinnati, OH), ‘‘Strong Evidence’’ was found associating WBV with low back pain.[34] Most of the ORs were 2 to 3, suggesting a moderately strong relationship. Nevertheless, most of the supportive data were derived from cross-sectional studies performed on drivers, and many data are more than 15 years old. Since that time, there have been improvements in vibration dampening equipment for drivers.[6] In addition, those data have also been undermined by a more recent systematic review, suggesting that there is no relationship between WBV and low back pain.[35] This raises the specter that the association is with time spent seated in conjunction with vibration rather than vibration alone.[36] The association between back pain and crashes may also be explained by medication use, specifically the use of narcotics for treatment of low back pain leading to increased risk of crash.[37] Regardless, the relationship between crash risk and low back pain requires further study.

Personal and Occupational Factors

Night shift work provided a protective association for reportable crash risk. Fewer drivers may be on the road during night time and may factor into a protective relationship. Drivers who work the night shift may also be more accustomed to the schedule than either swing or variable shift drivers.

Years as a professional driver is likely to have a relationship with lifetime prevalence of reported crash. Drivers who have been driving for a longer period of time (eg, 30 years) have more opportunities for a crash than those who have been driving for a short period of time (eg, 1 year). Unfortunately, we do not have access to incident data or did not collect the crash date(s) of those drivers reporting crashes.

Cell phone use, excluding texting, while driving in cities was associated with reportable crashes in this study. There were stronger relationships with approximately twofold increased crash risk found among those reporting higher cell phone usage (eg, daily or more than once a day as compared to never). This increased crash risk is congruous with prior reports of crashes and cell phone use in other populations. Cell use and other distractions have previously been associated with crash risk in the general population.[38–41] However, objective studies utilizing direct observation and quantification of eyes-off-road time and divided attention found that there was not an increased crash risk from cell phone use if eyes-off-road time segments were less than 2 seconds.[38–43] This study does not assess the potential relationships with crash while accounting for aversion of gaze or from hands-free devices.

Fatigue

Sleep issues are of interest to determine what specific factors are associated with fatigue and crash risk.[41,44,45] Fatigue issues, including sleep apnea, have been previously associated with risk of crash.[8,45,46] It seems likely that there is an underdiagnosis of obstructive sleep apnea in truckers due to the negative employment consequences. We believe that study participants were more likely to be truthful in reporting for this study because it was not performed in association with their employment, adhered to institutional research board confidentiality protection, and had further certificate of confidentiality protection for study subjects. Snoring was also examined as a potential proxy for sleep apnea risk. Neither snoring nor sleep apnea demonstrated significant associations with lifetime reportable crashes after adjustment for other factors.

Inclusion of both personal and occupational factors in the adjusted model elevated the *P* value for some factors. These include age, sex, past diagnosis of heart problems, past diagnosis of low back pain, feeling tense, and being mentally exhausted after work. This suggests that there is potential confounding in assessing relationships between occupational factors and personal factors and risks of crash. A purely personal factor model will not adequately control for confounding by occupational factors. Similarly, a purely occupational model will not adequately control for occupational factors. Although both domains have factors associated with crashes, these may not be independent domains and erroneous conclusions could be found if one domain is excluded. Regardless, one cross-sectional study, even if large, is insufficient to draw strong conclusions on risk factors.

Study strengths include the large, diverse population of active truck drivers who were recruited from a number of locations. The biometric data were also measured. These data are similar to data reported in other publications,[10,47] suggesting potential representativeness of the population of US truck drivers. In addition, this study assessed many factors including personal, occupational, and psychosocial. We are unaware of another study that has assessed relationships in these diverse domains. Study weaknesses include the self-reported nature of all of the health status and crash data. There also may be some self-selection bias toward healthier driver participation, although the comparability of the objective data with prior reports cast some doubt on that assumption.

CONCLUSIONS

This trucking population has many biometrics that are unhealthy, including high prevalence rates of obesity, uncontrolled hypertension, and hyperlipidemia. There are many personal and occupational factors that are associated with lifetime prevalence of crashes. Many of these factors, including psychosocial factors, may be modifiable and suggest that a targeted and effective wellness program among commercial drivers may have significant benefits in reducing the number of crashes, although the cross-sectional nature of this study suggests further investigations are warranted.

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