Multiple Conditions Increase Preventable Crash Risks among Truck Drivers in a Cohort Study

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Abstract

Objective—This study aims to quantify the crash risk for truck drivers with multiple comorbid medical conditions, after adjusting for confounders.

Methods—This retrospective cohort of 38,184 drivers evaluated concomitant medical conditions and subsequent crash data between 1/1/2005–10/31/2012. Hazard ratios (HRs) and 95% confidence intervals (95% CI) were calculated for any cause and preventable crashes of varying severity.

Results—Drivers with three or more medical conditions had significantly increased risk of preventable Department of Transportation (DOT) reportable crashes (HR=2.53, 95% CI=1.65–3.88) and preventable crashes with injuries (HR=2.23, 95% CI=1.09–5.31) after adjustment for covariates. Similarly, adjusted HRs were 2.55 (95% CI=1.37–4.73) for any cause DOT-reportable crashes and 3.21 (95% CI=1.18–8.75) for any cause crashes with injuries.

Conclusions—Having three concomitant medical conditions may be a statistically significant risk factor for preventable and any cause DOT-reportable crashes and crashes with injuries.

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Introduction

Commercial Motor Vehicle (CMV) drivers constitute one of the largest employment categories in the United States with an estimated 5.7 million CMV drivers, most of whom drive trucks.(1) Truck driving is also hazardous, as heavy and tractor trailer truck drivers in the US incurred 22.0 fatal injuries per 100,000 full-time equivalent workers in 2013, as compared to 3.4 per 100,000 full-time equivalent workers across all industries.(2) Every year since records were kept in 1975 through 2014, there has been an more than 3,100 large-truck crash fatalities in the US, with an upward trend over the past 5 years. (1, 3) Approximately 60,000 truck crashes with injuries were reported to the police over the past 5 years with an average cost per crash with injuries estimated to be between $331,000 and $533,000 and the average cost per crash involving a fatality between $7.2 and $11.7 million. (1, 3) It is estimated that 1,000 of the 3,700 yearly fatal truck crashes are believed to be due to the fault of the CMV driver, rather than another vehicle.(4) Some studies suggest these statistics are likely underestimates.(5–7)

CMV drivers are an understudied (8) and medically underserved (9) population, often lacking regular healthcare providers, having poor access to healthcare services and frequently relying on emergency rooms and urgent care centers. A recent systematic review of health promotion interventions among CMV drivers also concluded that they are currently an underserved occupational group in terms of healthcare and health promotion efforts which consistently has high rates of obesity and related co-morbidities.(10) CMV drivers with chronic medical conditions may present public safety concerns due to: (1) the size and speed of their vehicles, (11, 12) (2) the frequently poor functional status of these drivers, (11–14) (3), CMV driver's poor utilization of the traditional health care system (11–13) and (4) the large numbers and severe impacts of truck crashes on public health and safety.(11, 12) While compared to total crashes, the frequency of truck crashes is relatively low, however, crashes involving trucks are generally more severe.(4)

Commercial Driver Health and Safety

U.S. CMV drivers are required by Federal Motor Carrier Safety Administration (FMCSA) regulations to obtain medical examinations at least every 2 years in order to maintain their commercial driver's licenses. In spite of these required medical exams for licensure, commercial drivers have some of the highest rates of chronic diseases, occupational fatalities, and occupational injuries compared with other working populations.(15–23) While there are relatively few studies that have examined the association between crash risk and multiple medical condtions among CMV drivers, some published data have indicated an increased crash risk among obese CMV drivers.,(24, 25) cardiovascular disease,(15, 16, 26, 27) diabetes,(28) medication use, (29, 30), and sleep apnea.(31–33) One analysis reported that obese CMV drivers [body mass index (BMI)   30 kg/m^2] have a significantly higher crash rate (>2.0 times) than non-obese CMV drivers.(24) Another study found associations with obesity and crashes among newly recruited CMV drivers.(34)

The poor health status of CMV drivers is commonly attributed to lifestyle (improper diet, inadequate physical activity, and poor sleep hygiene) and work environmental factors, although few data are available to understand the relative importance of these factors.(35–

38) Combinations of medical conditions and/or medication use by drivers are suspected to increase their risk of being involved in crashes, however, there are no trucking-related data reported in this regard. (39) The only published study evaluating multiple medical conditions for drivers focused on general population, non-commercial drivers and found significantly increasing risks for crashes with increasing numbers of conditions.(40)

We hypothesized that there is an increased risk of preventable crashes among CMV drivers with multiple medical conditions in a large retrospective cohort after adjustments for confounding factors.

Methods

This study was approved by the University of Utah (IRB #35889) Institutional Review Board. This research linked two data sources using the driver's commercial driver license number, to investigate relationships between personal and environmental risk factors, and interactions between these factors, while controlling for covariates.

Data Sources

Commercial Driver Medical Exam (CDME) methods for this study have been previously described (41, 42)and thus are only briefly described below. [25,36] Road Ready's database is a large commercially-maintained dataset of CDMEs on drivers whose employers obtain CDMEs within the Road Ready network. The database includes CDMEs performed by numerous examiners on CMV drivers licensed in all 48 continental US states. Drivers are similar in health profiles (e.g. BMI, age, blood pressure, diabetes mellitus prevalence, etc.) to the overall truck driving population with an employer mix that includes private carriers, independent owner/operator drivers, and leased drivers for private carriers.(9, 15, 16, 20, 23, 43–48)

CDME, employment and crash data from January 1, 2005 to October 31, 2012 were analyzed. Data from before and after these times were not available. Data elements included: demographics (age and gender), medical history (e.g., neurological problems, medications, sleep disorders, diabetes mellitus), measured height, measured weight, calculated body mass index, blood pressure, heart rate, urinalysis, and other medical exams (e.g., vision, cardiovascular, hearing whisper test). For the present investigation, if drivers had multiple CDMEs in the 2005–2012 timeframe, only the first CDME was analyzed. CDMEs from the database were then further restricted to those of drivers from a single large trucking firm in order to match medical information with detailed crash data that would allow for the calculation of accurate estimates of crash risks (see below).

A large U.S. truck company's database (n~15,000 current drivers, n~70,000 drivers over the past 35 years) was accessed under a non-disclosure agreement. Company data included miles driven, segments driven, driving tenure, vehicle type, and all reported crashes involving the drivers.

Risk Factors

This study used the FMCSA Medical Review Board's (MRB) multiple conditions matrix to assign drivers to risk groups (left column of Table 1). The purpose of the matrix is to provide guidance regarding CMV driver certification length based on combinations of concomitant diseases and consensus opinion regarding increased risk for CMV crashes. Where exact matrix data were unavailable, comparable data were used for most elements from the CDME (right column of Table 1). As specified by the FMCSA MRB, the thirteen conditions are equally weighted within this matrix and were tallied to represent the number of medical conditions present for these analyses. This tool was selected as the primary measure because it is the only tool designed categorize drivers according to multiple concomitant conditions, with the presumption that there is an increased crash risk with increasing number of conditions. The temporal relationship between concomitant medical conditions and crashes has not been demonstrated.

Crash Occurrence and Outcomes

Crash data were accessed and the date of the crash was the event date. We considered only those crashes occurring subsequent to the CDME. The available crash data have multiple crash outcomes: 1) any crash, 2) DOT-reportable crash, and 3) DOT-reportable crash resulting in injuries. A crash of any severity was defined by the company as "any time the vehicle comes in contact with any other vehicle, object, person, animal, or property causing damage or injury or any allegation of contact or involvement in any manner, however minor." DOT-reportable crashes are a subset of total crashes where either: A) there is a fatality, B) one or more persons receives medical treatment away from the site of the crash as a result of injuries sustained from the crash, and/or C) where one or more vehicle(s) are towed from the scene. The most severe crash outcome evaluated is defined as a DOT-reportable crash resulting in either an injury or fatality. Consistent with other large programs in the industry, the company in this study has a crash investigation team that investigates all crashes and determines if the crash was or was not preventable. The determination is made by the company based on driver interviews, police reports, and other data. Preventable crashes are those crashes where the determination is that the crash could have been averted with driver action. Thus, all three crash outcomes were assessed in groups consisting of either preventable crashes, as well as in total (all crashes: both preventable and not preventable).

Covariates

Multiple covariates were assessed and adjusted for in the multivariable models (explained in the next section), including age, and gender, body mass index (BMI). Hazard ratios were also adjusted for: 1) length of medical certification, 2) reported narcotic or habit forming drug use, 3) if a drug test was performed at the time of the crash, 4) diagnosed muscular disease, 5) seat belt use at the time of the crash, 6) seizure history and 7) estimated impact speed of the crash. These were selected *a priori* based on potential for relationships with increasing number of medical conditions or increased severity of a crash.

Statistical Analyses

Analyses were performed using SAS 9.3 (SAS Institute, Cary NC, USA). Data were analyzed between 3/1/2015–3/28/16. Time-to-event data were available for all drivers. For those drivers not involved in a crash, theirhis or her last observation date in the study was the later of either a) the last date employed by the trucking company or b) the date his or her CDL was revoked due to a failed subsequent CDME. The latter criterion was also the same criterion for those with either single or multiple examinations. Time was calculated as the number of days between the exam and either crash or termination from the company. The analyses resulted in an estimated crash risk and adjusted hazard ratio for potential individual and environmental risk factors.

This study's unit of analysis is a single crash, with additional analyses of repeated crashes as separate observations. The outcomes are binary (e.g., crash vs. no crash). The main analyses were analyses of the recurrent (repeated) time-to-event data using the Prentice, Williams, Peterson (1981) conditional risk set model (under the proportional hazard) for ordered failure events.

In initial univariate analysis, the continuous variables (e.g., age and BMI) were assessed for linearity. When adjusting for confounder effects, we carefully assessed potential co-linearity between predictors. Model fit were assessed using Markov chain Monte Carlo algorithms and numerical integration using adaptive quadrature methods. Variables included in the model were selected *a priori* based on factors thought to influence crash and severity risk. The analysis plan was created prior to linking the data and evaluating relationships. All tests are two-sided, a p-value less than 0.05 indicates the statistically significant result. Missing data were excluded from analyses.

Results

There were 38,184 drivers (49,464 records) in the RR database who also had a driving record from the large truck company. There were 13,472 total crashes and 10,350 preventable crashes among these 38,184 drivers. The driver level descriptive statistics are provided in Table 2.

Any Crash

Among combined crashes of any severity, which includes minor crashes where no vehicles were towed, drivers having 4 or more medical conditions were significantly more likely to be involved in a crash (Table 3). A Kaplan-Meier Survival Curve (Figure 1) visually demonstrates the difference in probability of being crash-free between drivers with increasing number of multiple medical conditions. Our finding was present for the unadjusted model as well as both adjusted models (one model adjusted for age, gender, BMI; a second model adjusted for age, gender, BMI, certification length, drug use, drug test, muscular disease, seatbelt use, seizure history and speed). Univariate analyses, drivers with one medical condition were significantly less likely to be involved in either a crash of any severity or a preventable crash of any severity. However, this protective relationship for drivers with 1 condition was not present in either of the fully adjusted models, or in the

partially adjusted model for preventable crashes of any severity, suggesting the lack of an independently protective effect.

DOT Reportable Crashes

Among drivers with DOT-reportable crashes, the drivers with 3 medical conditions or 4 or more medical conditions were significantly more likely to be involved in a DOT-reportable crash and a preventable DOT-reportable crash. The hazard ratio was highest among drivers with 3 conditions and dropped slightly for those with 4 conditions. Drivers with one condition had a significantly protective hazard ratio for being in any DOT-reportable crash as compared to drivers with no medical conditions. Post hoc analyses excluding hypertension as one of the 13 medical conditions found there was no significant relationship between one medical condition and crash outcomes.

DOT Reportable Crashes with Injuries

Among drivers who had DOT-reportable crashes resulting in injuries, those drivers with 3 or more concomitant medical conditions were significantly more likely to be involved in both a crash resulting in injuries and a preventable crash resulting in injuries. These relationships remained after adjusting for potential confounders. It was not possible to adjust for all confounders seen in model 2 for other crash outcomes due to the small number of DOT-reportable crashes resulting in injuries.

There were many drivers who had two or more crashes, with most of them being any crash first followed by a DOT reportable crash or crash with injuries. Additional adjusted analyses were conducted which only included time-to-event to the first crash, then excluded from the study beyond that date. These analyses found meaningfully higher hazard ratios for both preventable DOT reportable crashes with injuries of any cause and preventable DOT crashes with injuries, with HR=5.12 (95% CI 1.14, 23.30) and HR=6.57 (95% CI 2.30, 18.81) respectively. Therefore, the true risk for having a preventable DOT reportable crash appears likely somewhere between the first-event hazard ratio estimate of 5.12 and the repeated-event hazard ratio estimate of 2.53. Similarly, the true risk for having a preventable DOT reportable crash with injuries is likely between the first-event hazard ratio estimate of 6.57 and the repeated-event hazard ratio estimate of 2.23. All of which were statistically significant.

Discussion

This large retrospective cohort study of commercial truck drivers found consistent relationships between multiple medical conditions and three different measures of crashes, including costly DOT-reportable crashes and crashes with injuries, with two- to three-fold increased risk estimates. Risks of being in a crash were elevated among truck drivers with either three, or four or more medical conditions. This is the first study to examine and quantify the assumption that multiple comorbid medical conditions are associated with an increased crash risk among truck drivers. These results support the MRB recommendations in that these drivers warrant increased scrutiny and have an increased risk of crash.

Furthermore, these data suggest multiple comorbid medical conditions are preventable causes of injuries and fatalities resulting from crashes.

There was dose response relationship between multiple concomitant medical conditions and DOT-reportable crash risk, but this relationship did not continue into the highest medical condition category (4 or more conditions) although it remained statistically significant yet lower than crash risk for drivers with 3 conditions. This may be due in part to a probable strong survivor bias in these data. Industry wide, if drivers are involved in a more severe crash (e.g., a DOT-reportable crash, particularly a crash with injuries), they are commonly removed from the driving pool, either through citation and loss of licensure, termination from the company, or prohibitive cost of repairing or insuring their vehicle if they are an owner operator. Smaller numbers of drivers with that many conditions may also limit the statistical power for greater numbers of medical conditions. The relative rarity of both numbers of drivers with 3 or more conditions and more severe crashes results in wide confidence bounds around the hazard ratio estimates. However, these hazard ratios are statistically significant and clinically meaningful, demonstrating a potentially causal association between having multiple medical conditions and subsequently having a crash. There is a meaningful difference in the crash risk estimate between those drivers with 2 conditions and those with 3 conditions. This may be due to residual confounding, interactions between multiple medical conditions, or differences in reporting. It is widely believed that there is under-reporting of medical conditions among drivers, therefore our estimates are likely an underestimation of the true risk for crashes. Recent articles reported that when the driver's BMI is >35 kg/m^2, >90% have objectively diagnosed obstructive sleep apnea (OSA) and at BMI of 40 kg/m^2 and above almost 100% have OSA.[33, 49] These data have lower self-reported sleep disorders for the number of drivers with BMI above 35 kg/m^2. Further research into these complex relationships and potential underreporting is needed.

Additionally, it is likely that these estimates are an underestimate of the true risk due to changes in exposure after having a crash. Drivers who had crashes of any severity and were still employed by the company remained in the risk pool for having a more severe crash. These drivers are given additional driving and crash-avoidance training or paired up with another driver-trainer. Therefore, their risk for a subsequent crash changes meaningfully after the first crash of any severity if they remained employed by the company. The data in the primary analyses in the tables assumes that there is no change in exposure which is not true, but is the most conservative assumption.

This study's strengths include the use of a large retrospective study with the ability to demonstrate temporality. Data were systematically captured across the population. The study was sufficiently powered to assess risk factor relationships with crash outcomes of three different severity measures. These findings may be generalizable to other trucking companies and other safety sensitive jobs. Another strength is the ability to assess the relationship between multiple comorbid conditions and differing severities of crash, including the DOT-reportable and preventable crashes, which are regarded as the most relevant in the trucking industry. Weaknesses include data that are limited to those collected as part of the CDME and the company. These data are comparable to other studies among

commercial truck drivers as well as data from the American Trucking Association survey of members performed in 2010. There is no potential to gather additional data such as primary care provider records, and therefore we are unable to address additional factors that could cause or contribute to crashes that are not addressed in this study and may have importance in the commercial truck driving population. The hazard ratio estimates are calculated from relatively small numbers of drivers with 3 or more medical conditions and few crashes. These small sample sizes result in wider confidence bounds and limited ability to arrive at definitive conclusions. While the hazard ratio estimates may fall within a large range, these demonstrated temporal relationships between multiple conditions and multiple types of crash are statistically significant. Care should be taken when interpreting the true crash risk from multiple medical conditions due to the small sample size and rarity of some crash events. Additionally, although we did statistically adjust for BMI, many of the medical conditions have relationships with obesity. There are demonstrated relationships with increasing BMI and increasing counts of medical conditions.(41) Particularly, the relationship between increasing BMI and higher prevalence of OSA, which has repeatedly shown an association with crash risk, may be partially responsible for the increased risk of having a crash seen in these analyses.(49, 50) Similarly, age and male gender are associated with many of these health factors. We statistically adjusted for these confounding factors as well as BMI, however residual confounding may still exist. While we did perform analyses to control for driving tenure at the company, that was not a meaningful confounder in multivariate models and was not included in final models. However, age was included in final models and is generally collinear with driving experience. Unfortunately, the available data do not include total driving experience as a potential confounding factor, as only the tenure at the individual company was available. We evaluated company tenure and miles driven as potential confounders and found they had limited impact on the relationships between multiple medical conditions and crash risk and were not included in the final model.

Conclusion

Multiple comorbid medical conditions appear to be a risk factor for three different measures of crashes in this large population of CMV drivers. Risk estimates were more than two- to three-fold increased. This study supports the FMCSA Medical Review Board's recommendations insofar as drivers with multiple conditions are at increased risk of being involved in a crash and therefore, merit additional scrutiny during medical certification examinations. These relationships remained after controlling for important confounders. Further research should focus on the identification of specific conditions from the multiple conditions matrix that increase crash risk, and that may be amenable to more aggressive treatment and more restrictive limits on driver certification that may reduce the risk of preventable crashes and related injuries and fatalities to truck drivers and the traveling public.

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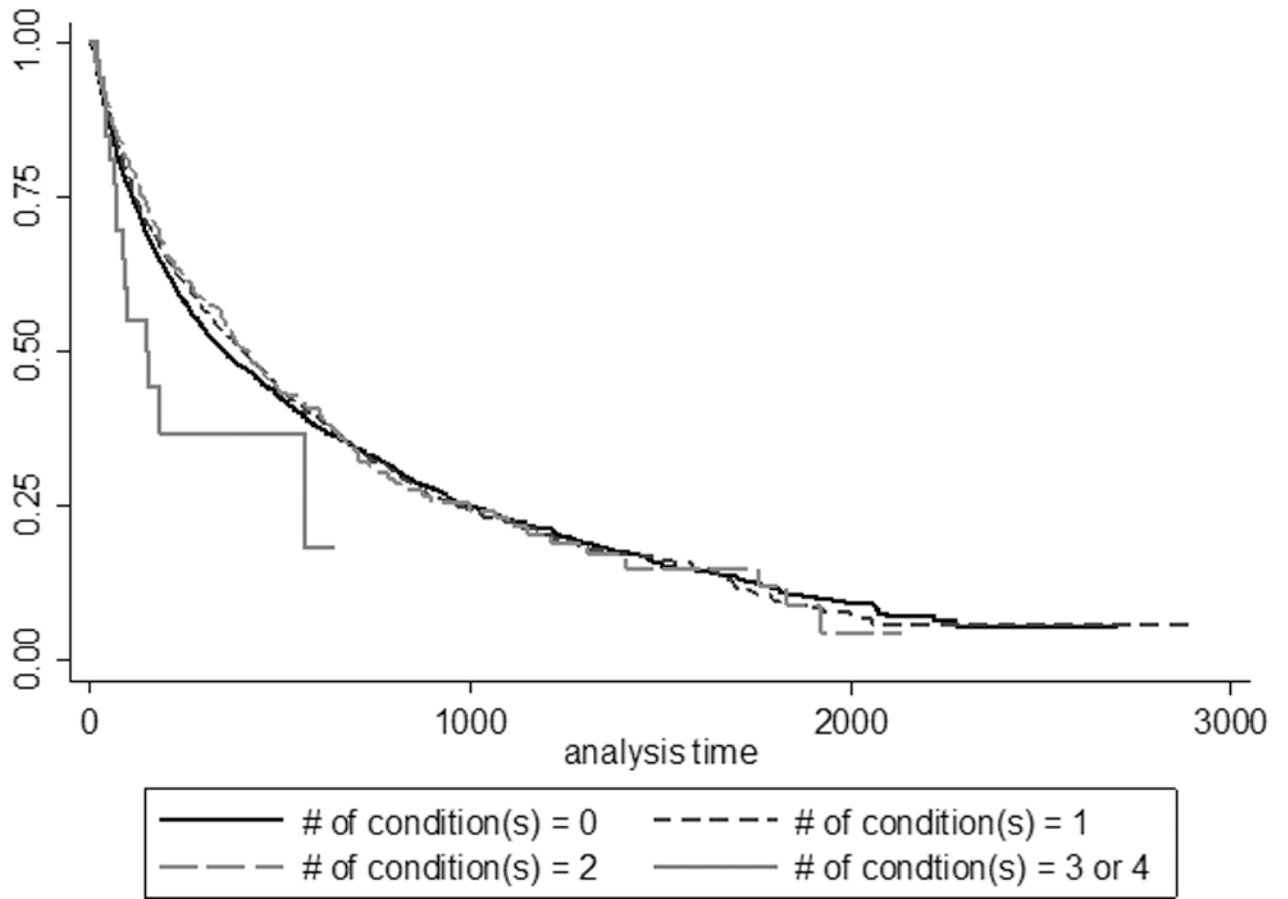
Figure 1.
Survival Curve Demonstrating Survival Stratified by the Number of Conditions for Any Crash Event.

Table 1

Multiple Conditions Matrix and Data Used from the Exam Form for each Condition

Multiple conditions for qualified certification time from the Federal Motor Carrier Safety Administration's Medical Review Board [31, 32]	Data used in this analysis from the Road Ready database of Commercial Driver Medical Exam forms
1. Body mass index>35 kg/m^2	Body mass index>35 kg/m^2
2. Diabetes mellitus requiring medication	Diabetes mellitus controlled by medication
3. Cardiovascular disease or Dysrhythmias	Heart disease, heart surgery or heart abnormalities
4. Hypertension	Elevated blood pressure above 140/90 mmHg, or hypertension medication, or self-reported history of hypertension
5. Requirement for a visual exemption	Corrected vision in both eyes worse than 20/40 or horizontal field of vision <70° degrees in either eye
6. Obstructive sleep apnea	Sleep problems
7. Renal disease	Kidney disease
8. Pulmonary disease with pulmonary function test abnormality	Lung and chest abnormalities
9. Epilepsy seizure free for >10 years	Seizures/epilepsy
10. Musculoskeletal disease requiring medical, surgical or prosthetic treatment	Spine or other musculoskeletal disorder
11. Stroke	Stroke or paralysis
12. Major psychiatric illness (as defined pending formal review by the Medical Review Board)	Nervous or psychiatric disorders
13. Opioid or benzodiazepine use	Opioid or benzodiazepine medication, including generic and trade names, in the record

Table 2

Descriptive Statistics Stratified by Number of Concomitant Medical Conditions

Variablen (%) or mean ± SD	0 Conditions (N=32,697, 66.10 %)	1 Condition (N=14,684, 29.69 %)	2 Conditions (N=2,001, 4.05%)	3 or more conditions (N=82, 0.17 %)	Total (N=49,464)
Age	47.4 ±10.4	47.4 ±10.4	48.7 ±10.2	50.4 ±11.3	47.4 ±10.4
Body Mass Index	28.1 ±3.9	37.8 ±7.3	39.7 ±6.7	39.7 ±6.3	31.4 ±7.1
Gender (male)	31401 (96.0%)	13840 (94.2%)	1922 (96.0%)	81 (98.8%)	47244 (98.8%)
BMI Category					
Underweight below 18.5	197 (0.60%)	10 (0.07%)	0	0	207 (0.42%)
Normal Wt. 18.5–24.9	7258 (22.2%)	590 (4.0%)	31 (1.6%)	0	7879 (15.9%)
Overweight 25.0–29.9	13817 (42.3%)	1605 (10.9%)	109 (5.4%)	4 (4.9%)	15535 (31.4%)
Obese 30.0–34.9	11408 (34.9%)	1563 (10.6%)	103 (5.6%)	0	13074 (26.4%)
Morbidly Obese 35.0	17 (0.05%)	10916 (74.3%)	1758 (87.9%)	78 (95.1%)	12769 (25.8%)
Diabetes Mellitus	1420 (4.3%)	1396 (9.5%)	212 (10.6%)	9 (11.0%)	3037 (6.1%)
Heart Disease	0	238 (1.6%)	234 (11.7%)	44 (53.7%)	516 (1.0%)
High Blood Pressure	3637 (11.1%)	3600 (24.5%)	675 (33.7%)	30 (36.6%)	7942 (16.1%)
Nervous Disorders	460 (1.4%)	319 (2.2%)	39 (2.0%)	2 (2.4%)	820 (1.7%)
Sleep Disorders	244 (0.8%)	539 (3.7%)	77 (3.8%)	3 (3.7%)	863 (1.7%)
Chronic Low Back Pain	157 (0.5%)	101 (0.7%)	20 (1.0%)	0	278 (0.6%)
Seizure Epilepsy	18 (0.06%)	2 (0.01%)	0	0	20 (0.04%)
Certification Length					
Failed	312 (1.0%)	366 (2.5%)	118 (5.9%)	8 (9.8%)	804 (1.6%)
Periodic	5951 (18.2%)	6670 (45.4%)	1549 (77.4%)	65 (79.3%)	14235 (28.8%)
Qualified	26059 (79.7%)	7293 (49.7%)	227 (11.3%)	1 (1.2%)	33580 (67.9%)
Temp Disqualified	375 (1.2%)	355 (2.4%)	107 (5.4%)	8 (9.8%)	845 (1.7%)
Drug Use	43 (0.1%)	17 (0.1%)	2 (0.1%)	1 (1.2%)	63 (0.1%)
Miles Driven	74322.9 ±108745.2	78715.8 ±112062.7	64582.2 ±90563.9	29014.5 ±38126.4	75234.8 ±109119.1
Drug test	191 (2.2%)	95 (2.3%)	11 (2.2%)	1 (5.3%)	298 (2.2%)
Speed category					
0	6822 (20.9%)	3089 (21.0%)	379 (18.9%)	14 (17.1%)	10304 (20.8%)

Variablen (%) or mean ± SD	0 Conditions (N=32,697, 66.10 %)	1 Condition (N=14,684, 29.69 %)	2 Conditions (N=2,001, 4.05%)	3 or more conditions (N=82, 0.17 %)	Total (N=49,464)
1–51	1436 (4.4%)	640 (4.4%)	76 (3.8%)	5 (6.1%)	2157 (4.4%)
51–80	631 (1.9%)	341 (2.3%)	39 (2.0%)	0	1011 (2.0%)
Seatbelt use	3233 (96.3%)	1624 (95.5%)	209 (96.8%)	7 (77.8%)	5073 (96.0%)
Crash with fatalities	16 (0.05%)	8 (0.05%)	3 (0.2%)	0	27 (0.05%)
DOT reportable Crash	782 (2.4%)	387 (2.6%)	43 (2.2%)	4 (4.9%)	1216 (2.5%)
DOT reportable injuries	206 (0.6%)	91 (0.6%)	13 (0.6%)	2 (2.4%)	312 (0.6%)
Preventable crashes	6876 (21.03)	3092 (21.06)	369 (18.49)	13 (15.85)	10350 (20.92)

Note Drug use defined as self-reported narcotic or habit forming drug use N=44,182, missing information of seatbelt use at the time of the crash. N=35,992 missing data for drug test after a crash. N=4 missing for heart disease. N=35,992 missing for speed category. N=35,992 missing for DOT reportable injuries.

Table 3

Hazard Ratios and Confidence Intervals for Concomitant Medical Conditions and Any Cause or Preventable[‡] Crashes

Number of Conditions	Crash of Any severity		Preventable[‡] Crash of Any Severity	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Unadjusted				
0	1.00	Reference	1.00	Reference
1	**0.94**	**0.90** 0.98	**0.93**	**0.89** 0.97
2	0.92	0.84 1.01	0.89	0.80 1.00
3	1.15	0.71 1.87	1.00	0.60 1.65
4 or more	**3.63**	**3.51** 3.76	N/A	N/A
Model 1 [*]				
0	1.00	Reference	1.00	Reference
1	1.02	0.96 1.09	1.03	0.95 1.12
2	1.01	0.91 1.13	1.01	0.89 1.15
3	1.27	0.79 2.06	1.13	0.69 1.87
4 or more	**4.16**	**3.85** 4.51	N/A	N/A
Model 2 [†]				
0	1.00	Reference	1.00	Reference
1	1.03	0.92 1.15	1.05	0.93 1.19
2	1.08	0.91 1.3	1.11	0.90 1.35
3	1.32	0.84 2.1	0.98	0.62 1.53
4 or more	**2.01**	**1.72** 2.34	N/A	N/A

Number of Conditions	DOT Reportable Crash		Preventable[‡] DOT Reportable Crash	
	Hazard Ratio	95% Confidence Interval	Hazard Ratio	95% Confidence Interval
Unadjusted				
0	1.00	Reference	1.00	Reference
1	**0.85**	**0.75** 0.96	**0.89**	**0.77** 1.04
2	0.97	0.76 1.24	0.9	0.55 1.47
3	**2.79**	**1.63** 4.74	**1.73**	**1.46** 2.04
4 or more	**1.78**	**1.58** 2.01	N/A	N/A
Model 1 [*]				
0	1.00	Reference	1.00	Reference
1	0.83	0.65 1.05	1.06	0.82 1.39
2	0.94	0.67 1.32	1.11	0.63 1.93
3	**2.63**	**1.49** 4.89	**2.15**	**1.54** 3.01

Number of Conditions	Hazard Ratio	95% Confidence Interval		Hazard Ratio	95% Confidence Interval	
		Crash of Any severity			Preventable‡ Crash of Any Severity	
4 or more	1.72	1.30	2.29	N/A		
Model 2 †						
0	1.00	Reference	1.00	Reference		
1	0.73	0.43	1.23	1.12	0.84	1.49
2	0.97	0.53	1.75	1.2	0.66	2.20
3	2.55	1.37	4.73	2.53	1.65	3.88
4 or more	1.62	0.91	3.11	N/A		
		DOT Reportable Crash with Injuries			Preventable‡ DOT Reportable Crash with Injuries	
Unadjusted	1.00	Reference	1.00	Reference		
1	0.86	0.66	1.11	0.96	0.70	1.32
2	0.97	0.61	1.55	0.94	0.46	1.89
3 or more	3.36	1.43	7.91	2.01	1.41	2.83
Model 1 *	1.00	Reference	1.00	Reference		
1	0.78	0.46	1.32	1.01	0.47	2.15
2	0.89	0.45	1.77	1.01	0.38	2.65
3 or more	3.21	1.17	8.75	2.23	1.09	5.31

*
Adjusted for Age, Gender and BMI

†
Adjusted for Age, Gender, BMI, Certification Length, Drug Use, Drug Test, Muscular Disease, Seatbelt Use, Seizure History and Speed

N/A- Not available, there were not enough preventable crashes to create a stable estimate for 4 or more medical conditions.

‡
Preventable crashes are those identified as being preventable by the company's crash investigation team