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Commercial Driver Medical Examinations

Prevalence of Obesity, Comorbidities, and Certification Outcomes

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Objective: The objective of this study was to assess relationships between body mass index (BMI) and comorbid conditions within a large sample of truck drivers. **Methods:** Commercial driver medical examination data from 88,246 commercial drivers between 2005 and 2012 were analyzed for associations between BMI, medical disorders, and driver certification. **Results:** Most drivers were obese (53.3%, BMI >30.0 kg/m^2) and morbidly obese (26.6%, BMI >35.0 kg/m^2), higher than prior reports. Obese drivers were less likely to be certified for 2 years and more likely to report heart disease, hypertension, diabetes mellitus, nervous disorders, sleep disorders, and chronic low back pain (all $P < 0.0001$). There are relationships between multiple potentially disqualifying conditions and increasing obesity ($P < 0.0001$). Morbid obesity prevalence increased 8.9% and prevalence of three or more multiple conditions increased fourfold between 2005 and 2012. **Conclusions:** Obesity is related to multiple medical factors as well as increasing numbers of conditions that limit driving certification.

Commercial motor vehicle (CMV) drivers are the 13th largest employment category in the United States with an estimated 5.7 million CMV drivers in 2012.[1] In 2011, there were 3341 fatal large truck crashes and approximately 60,000 crashes with injuries that were reported to the police.[1] The average cost per crash with injuries has been estimated at $533,000 ($32 billion total), and the average cost per crash involving a fatality is approximately $11.7 million ($39 billion total).[1] Although CMV drivers represent a modest share of the workforce, they are a high impact group because of[1] occupational risks from the size and speed of their vehicles,[2] frequently poor health status, and[3] the large impact of truck crashes on public health and safety.[2–5] Research on CMV drivers demonstrates highly prevalent reported obesity (BMI >30.0 kg/m^2) and they have considerable health issues, including those commonly attributed to lifestyle and occupational factors (eg, improper diet, inadequate physical activity, poor sleep hygiene, and shift work).[6–12]

To address public and driver safety, CMV drivers are required to undergo and pass a commercial driver medical examination (CDME) at least once every 2 years to maintain a Commercial Driver's License. The CDME requires the examiner to note the presence and absence of multiple potentially disqualifying conditions. These CDMEs may be challenging as CMV drivers may have multiple conditions.

Among the sparsely reported data, CMV drivers have a high risk of chronic diseases, particularly diabetes mellitus, hypertension, and premature heart disease as compared to general population and other occupational cohorts.[13,14] There have been some reports evaluating relationships between obesity and factors within CMV driving population.[11,15–18] Obese CMV drivers may also be prone to crashes, with a significantly higher crash rate (more than two times) compared with nonobese CMV drivers.[19,20]

Combinations of medical conditions and/or medication use are believed to increase the risk for crashes.[21] Crashes from combinations of risk factors were one of the triggering events behind the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for User legislation in 2004 to revise the process for certifying medical fitness to drive.[22] Yet, over the subsequent 10 years that have included 15 Evidence Reports and 10 Medical Expert Panels,[21,23] there is no evidence report and only one guideline for qualifying individuals with multiple medical conditions (see Table 1).[24] That guideline recommends shortened certification intervals, preclusion of certification after four or more conditions are diagnosed, and higher medical training requirements when there are multiple medical conditions.[23,24] Nevertheless, that guideline's impacts have not been systematically studied.

As a first step, the objective of this paper was to present an analysis of relationships between obesity and other chronic conditions to develop a foundation for further research evaluating CMV driver health and potential safety risks. The second objective was to describe the potential impact of the Medical Review Board's multiple conditions matrix.

METHODS

This study was approved by the University of Utah Institutional Review Board (#35889). Commercial driver medical examination data were obtained from RoadReady, Inc (RR), a private company that provides a Web-based platform for clinicians to electronically capture CDME findings and certification decisions. The RR database includes CDMEs performed by numerous examiners on CMV drivers licensed in all 48 lower states. Drivers in the database are employed by private carriers as well as independent owner/operator drivers, some of which are leased drivers for private carriers. The majority of the drivers are classified as over-the-road or long-haul drivers.

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This research has been approved by the Institutional Review Board of the University of Utah.

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TABLE 1. Multiple Conditions Matrix and Data Used From the CDME Form for Each Condition

Multiple Conditions for Qualified Certification Time From the FMCSA's Medical Review Board[19,20]	Data Used in This Report From the Road Ready Database of CDME Forms for These Analyses
Body mass index >35 kg/m^2	Body mass index >35 kg/m^2
Diabetes mellitus requiring medication	Diabetes mellitus controlled by medication
Cardiovascular disease or dysrhythmias	Heart disease, heart surgery, or heart abnormalities
Hypertension	Elevated blood pressure higher than 140/90, or hypertension medication, or self-reported history of hypertension
Requirement for a visual exemption	Corrected vision in both eyes worse than 20/40 or horizontal field of vision <70° in either eye
Obstructive sleep apnea	Sleep problems
Renal disease	Kidney disease
Pulmonary disease with pulmonary function test abnormality	Lung and chest abnormalities
Epilepsy seizure free for >10 yrs	Seizures/epilepsy
Musculoskeletal disease requiring medical, surgical, or prosthetic treatment	Spine or other musculoskeletal disorder
Stroke	Stroke or paralysis
Major psychiatric illness (as defined pending formal review by the Medical Review Board)	Nervous or psychiatric disorders
Opioid or benzodiazepine use	Opioid or benzodiazepine medication, including generic and trade names, in the record

CDME, commercial driver medical examination; FMCSA, Federal Motor Carrier Safety Administration.

At the completion of each CDME, the examiner determines whether the driver meets the requirements for unrestricted certification (up to 2 years), shortened certification, or does not meet the medical requirements. When RR is used, examination data are entered by the clinics into a computer program to improve data quality and capture. Data from RR from January 1, 2005, to October 31, 2012, were analyzed. Data elements included demographics (age and sex), medical history (eg, neurological problems, medications, sleep disorders, and diabetes mellitus), measured height, weight (for body mass index) and blood pressure, heart rate, urinalysis, and other medical examinations (eg, vision, cardiovascular, and hearing whisper test). If drivers have multiple consecutive CDMEs in the RR database, only the first CDMEs were analyzed. Data regarding the type of driver are not available; however, estimates of driver type are that the large proportion (more than 75%) are over the road drivers, with the remaining roughly equally divided between local and regional drivers.

A total of 96,591 CDMEs were in the Road Ready database, encompassing all CDMEs performed from January 1, 2005, to October 31, 2012. A total of 8345 (8.6%) were excluded because of second ($n = 7939$) and third ($n = 6$) examinations of the same driver or incomplete data or erroneous BMI measures ($n = 400$; BMI < 10.5 kg/m^2 or >100 kg/m^2).

Disqualifying Conditions

The Federal Motor Carrier Safety Administration (FMCSA) has provided multiple sources of guidance for examiners when conducting a CDME. This guidance is drawn from multiple sources including conference reports, evidence summaries, medical expert panel recommendations, Medical Review Board recommendations, FMCSA's Handbook, and other documents.[21,23,25] In the near-total absence of standardized or regulatory criteria for examiners to conclude an evaluation, decisions on limited qualification and/or temporary disqualification of a driver's Commercial Driver's License is left by FMCSA to the examiner's discretion. Certification length of less than 2 years may be granted by the examiner, based on guidance, judgment, and risks associated with the CMV driver's condition(s). Benchmarking examples from FMCSA include 1-year certifications for those with either hypertension or diabetes mellitus without any other condition.[26] There are few absolutely disqualifying conditions (legal blindness, uncontrolled seizures due to epilepsy, etc), although there are many conditions that are disqualifying with few exceptions including but not limited to:

1. Corrected vision in one eye worse than 20/40
2. Horizontal field of vision less than 70°
3. Color vision deficiencies
4. Unable to hear a forced whisper at 5 feet
5. Insulin-dependent or uncontrolled diabetes mellitus
6. Epilepsy
7. Anticonvulsion medication for treatment of seizures or epilepsy
8. Blood pressure above 180/110
9. Untreated respiratory dysfunction
10. Implanted defibrillator
11. Supplemental oxygen use
12. Unstable mental conditions and psychoses
13. Current alcoholism
14. Use of schedule 1 drugs or methadone

This study used the FMCSA Medical Review Board's multiple conditions matrix using comparable data for most elements from the CDME (see Table 1). The purpose of the matrix is to provide guidance regarding CMV driver certification length on the basis of combinations of risks. All conditions within this matrix are weighted equally. For analyses of the matrix in this paper, counts of relative disqualifying conditions were analyzed in relationship to BMI categories. Application of the multiple conditions table (Table 1) from the Medical Review Board recommendations on the RR data was analyzed. The proportion of drivers who would not be qualified on the basis of self-reported conditions and measured results when applying the matrix was determined.

Statistical Analysis

Analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC). The data set that was analyzed included all complete first CDMEs for each driver that were in the RR system. The focus

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of these analyses was to assess relationships between factors and BMI categorization. Data were stratified by BMI category into underweight (BMI <18.5 kg/m^2), normal weight (BMI ≥18.5 kg/m^2 to <25.0 kg/m^2), overweight (BMI ≥25.0 kg/m^2 to <30.0 kg/m^2), obese (BMI ≥30 kg/m^2 to <35 kg/m^2), and morbidly obese (BMI ≥35 kg/m^2). Mean and standard deviations are presented. Assessment of normality was performed for numeric variables of age, BMI, systolic blood pressure, diastolic blood pressure, and heart rate were found to be skewed. Categorical variables were analyzed using the Fisher exact test, and numeric variables were analyzed using the Kruskal-Wallis test to evaluate these relationships. We also performed the Barnard tests on those analyses with large sample sizes. There were no meaningful differences between results from the Barnard tests and the Fisher tests. Logistic regression was used to quantify the magnitude and direction of association between BMI category and CDME measures. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for age and sex in a multivariate logistic regression. No comparisons were made between unadjusted and adjusted ORs. Comparisons between first and second were stratified by BMI category and evaluated using the Signed Rank test.

RESULTS

Among the 88,246 drivers with one CDME who were eligible for analysis, the majority of participants were obese with a BMI 30.0 kg/m^2 or more (53.2%) (see Fig. 1). The proportions with a BMI 35.0 or more and 40.0 kg/m^2 or more were 26.6% and 12.1%, respectively (not all data in figure).

Table 2 reports demographic and population descriptive data stratified by BMI groups. There are statistically significant trends going from normal weight to morbidly obese drivers, where the higher BMI categories are more likely to be older, have increases in measured systolic and diastolic blood pressure, and were more likely to receive less than the maximum 2-year certification. The relationship between BMI category and sex were not monotonic with a somewhat higher frequency of females in the underweight and morbidly obese categories. The probability of a full 2-year certification declined markedly from those underweight (84.4%) and normal weight (81.2%) to 46.2% of those morbidly obese ($P < 0.0001$). A statistically significant proportion of overweight, obese, and morbidly obese CMV drivers was disqualified or given limited certifications. There was a sixfold risk of shortened certification length comparing morbidly obese to normal weight drivers (crude OR = 6.00; 95% CI, 5.69 to 6.33).

Health History Results

There were many significant relationships between CDME health history questions and BMI categories (Table 3). After age and sex adjustments, drivers who were overweight, obese, and morbidly obese were more likely to have shortened certification, report having had an injury or illness in the past 5 years, head or brain injuries, heart disease, taking medication for heart disease, had heart surgery, hypertension, to be taking medication for hypertension, lung disease, shortness of breath, digestive problems, diabetes mellitus, controlling diabetes mellitus with diet, controlling diabetes mellitus with pills, nervous disorders, taking medication for nervous disorders, sleep disorders, spinal injury or disease, chronic low back pain, and requiring vision correction. The prevalence of diabetes mellitus rose from 1.9% of those underweight or normal weight to 12.6% among those morbidly obese ($P < 0.0001$). The prevalence of self-reported sleep disorders also rose among those underweight (0.2%) or normal weight (0.7%) to 6.7% of those morbidly obese ($P < 0.0001$). Frequencies and proportion of each health history question are provided in supplemental tables (see supplemental digital contents Table S1, available at http://links.lww.com/JOM/A197).

There are many strong associations (ORs >3.0 [23, 24]) between health history and both obese and morbidly obese BMI categories. For obese drivers strong associations exist for high blood pressure (OR = 3.61), diabetes mellitus (OR = 4.15), and sleep disorders (OR = 5.49) as compared to normal weight drivers. Morbidly obese drivers are strongly associated with having less than a 2-year certification (OR = 6.00), high blood pressure (OR = 6.94), diabetes mellitus (OR = 7.99), and sleep disorders (OR = 28.59) as compared to normal weight CMV drivers. Conversely, morbidly obese drivers are less likely to have had a seizure or epilepsy (OR = 0.17).

Physical Examination Results

Significant associations were found between BMI categories and physical examination results (see supplemental digital contents Table S3, available at http://links.lww.com/JOM/A195). After adjustment for age and sex, overweight and obese drivers were more likely to have abnormal examination findings for general appearance, heart, mouth, abdomen, and vascular system as compared to normal weight drivers. The trend for general appearance was nonlinear with higher prevalence of abnormalities among the underweight and morbidly obese as compared to normal. Increasing prevalence of abnormalities was associated with increasing BMI categories for abnormalities noted in participant's proteinuria and glucosuria (data not shown). The ORs indicate that overweight (OR = 7.32), obese (OR = 43.15), and morbidly obese (OR = 154.60) drivers have strong associations with the examination findings of abnormal general appearance. Frequencies and proportion of each physical examination finding and urinalysis results are provided in supplemental tables (see supplemental digital contents Table S2, available at http://links.lww.com/JOM/A196).

Multiple Conditions Matrix Results

The relationship between obesity and the multiple conditions matrix (Table 1) was highly significant ($P < 0.0001$) and is shown in Table 4. This estimate is derived from following the multiple conditions matrix guidelines, which suggest that CMV drivers with four or more conditions should not be certified. These relationships indicate that there is a strong relationship between increasing obesity and the likelihood of having multiple conditions. Without consideration of the certification criterion of BMI and using the criterion of four or more conditions that preclude certification, it is estimated that less than 5 drivers (less than 0.1%) of those normal weight, 17 (0.1%) of those overweight, 50 (0.2%) of those obese, and 107 (0.4%) of those morbidly obese would not be certified until resolution of at least one condition. In addition, when including the BMI more than 35 kg/m^2 criteria, there were 782 drivers (0.9% of total drivers) who had four or more conditions and would not be eligible for certification until

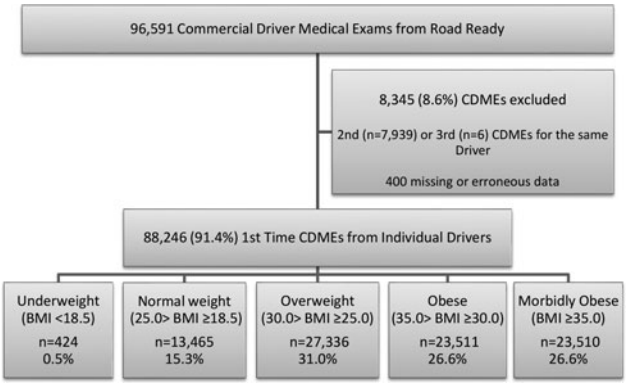

FIGURE 1. Flow chart of commercial driver medical examination data.

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TABLE 2. Demographic Data From Commercial Driver Medical Examination With *P* Value for Differences Between BMI Categories

	Underweight (BMI <18.5, *n* = 424)	Normal Weight (25 > BMI ≥ 18.5, *n* = 13,465)	Overweight (30.0 > BMI ≥25.0, *n* = 27,336)	Obese (35 > BMI ≥ 30, *n* = 23,511)	Morbidly Obese (BMI ≥ 35, *n* = 23,510)	Total (*n* = 88,246)	*P*
Age (yrs)							
Median	**40.0**	**44.0**	**47.0**	**47.0**	**45.0**	**46.0**	**<0.0001**
Mean (SD)	**42.3 (11.5)**	**44.6 (11.1)**	**46.9 (10.4)**	**46.9 (10.1)**	**45.1 (10.0)**	**46.0 (10.4)**	
BMI (kg/m^2)							
Median	17.7	23.0	27.6	32.2	39.5	30.5	NA
Mean (SD)	17.3 (1.5)	22.7 (1.6)	27.6 (1.4)	32.3 (1.4)	41.1 (5.7)	31.7 (7.2)	
Systolic pressure							
Median	**118.0**	**120.0**	**124.0**	**128.0**	**130.0**	**126.0**	**<0.0001**
Mean (SD)	**116.8 (13.0)**	**121.1 (13.0)**	**125.7 (13.0)**	**128.1 (12.7)**	**130.3 (12.6)**	**126.8 (13.2)**	
Diastolic pressure							
Median	**76.0**	**80.0**	**80.0**	**82.0**	**84.0**	**82.0**	**<0.0001**
Mean (SD)	**74.6 (9.0)**	**77.4 (8.5)**	**80.5 (8.0)**	**82.0 (7.7)**	**83.1 (7.5)**	**81.1 (8.1)**	
Heart rate (bpm)							
Median	**72.0**	**72.0**	**76.0**	**76.0**	**78.0**	**76.0**	**<0.0001**
Mean (SD)	**73.9 (9.6)**	**73.6 (9.0)**	**75.1 (9.2)**	**76.4 (9.0)**	**78.4 (9.1)**	**76.1 (9.3)**	
Sex							
Male	**390 (92.0%)**	**12,878 (95.6%)**	**26,450 (96.8%)**	**22,584 (96.1%)**	**22,057 (93.8%)**	**84,359 (95.6%)**	**<0.0001**
Female	**34 (8.0%)**	**587 (4.4%)**	**886 (3.2%)**	**927 (3.9%)**	**1,453 (6.2%)**	**3,887 (4.4%)**	
Certification time							
Qualified (2 yrs)	**358 (84.4%)**	**10,940 (81.2%)**	**19,417 (71.0%)**	**14,470 (61.5%)**	**10,870 (46.2%)**	**56,055 (63.5%)**	**<0.0001**
Periodic (<2 yrs)	**33 (7.8%)**	**1,748 (13.0%)**	**6,145 (22.5%)**	**7,261 (30.9%)**	**9,942 (42.3%)**	**25,129 (28.5%)**	
Temporary disqualified	**15 (3.5%)**	**301 (2.2%)**	**798 (2.9%)**	**763 (3.2%)**	**1,076 (4.6%)**	**2,953 (3.3%)**	
Disqualified	**18 (4.2%)**	**476 (3.5%)**	**976 (3.6%)**	**1,017 (4.3%)**	**1,622 (6.9%)**	**4,109 (4.7%)**	

BMI, body mass index; NA, not available; SD, standard deviation.
Bold in text highlights statistically significant relationships ($P < 0.05$).

the number of relative disqualifying conditions dropped less than four.

Change Over Time

Analyses were performed to evaluate differences in measures over time, as measured by calendar year (Figure 2). The highest number or CDMEs occurred in 2007, with 18,317 (20.9%) examinations performed in that period, and the lowest in 2010 with 6322 (7.2%) examinations. Across those years (2005 to 2012) there were significant differences as well as trends over time in multiple CDME measures.

Among the medical history variables, there were significant differences and trends with increasing prevalence of diabetes mellitus, as shown in Fig. 1. Significant trends among prevalence of underweight (0.7% to 0.3%), normal weight (19.4% to 11.2%), and overweight (32.4% to 29.3%) BMI categories among CMV drivers were seen. Conversely, significant positive trends over the 2005 to 2012 time period were seen among obese (25.3% to 28.2%) and morbidly obese (22.2% to 31.1%) BMI categories of CMV drivers. Mean weight of drivers increased significantly from 211 lb to 227 lb Mean BMI increased from 30.6 kg/m^2 to 32.6 kg/m^2. Conversely, mean age significantly decreased from 47.1 to 44.1 years old.

There is a trend for increasing number of multiple conditions from the multiple conditions matrix over time, with a quadrupling of the proportion that have four or more conditions (0.5% to 2.3%). A threefold increase was seen among those with three conditions (2.7% to 8.8%).

DISCUSSION

This study provides a unique glimpse into the health aspects of more than 85,000 truck drivers. A key finding resulted from the breakdown of BMI across this group—53.3% of the drivers were obese (BMI ≥30.0 kg/m^2), 26.6% were morbidly obese (BMI ≥35.0 kg/m^2), and 12.1% were extremely obese (BMI ≥40.0 kg/m^2). Within the entire sample, the average BMI was 31.7 kg/m^2. Comparing these results with subjective, self-reports from CMV drivers, the findings in this study are somewhat higher than previously reported data. In a study that surveyed drivers at truck stops in Tennessee, 37% of the drivers had an overweight BMI, whereas 45% were classified as obese. A national study found that 22.8% were overweight and 68.9% were obese.[14] Another large study reported a prevalence proportion of more than 50% obesity among more than 19,000 drivers.[27] It is noteworthy that this study found that substantial proportions of drivers are above any of the varying BMI screening threshold criteria that range from 30.0 to 35.0 kg/m^2 for sleep apnea, a noted factor associated with drowsy driving.[23,25]

The FMCSA Medical Review Board developed the multiple conditions matrix over 3 years (Table 1) as a guideline for examiners to be able to address interactions among multiple risk factors for crashes to be used in certifying drivers. This study is the first reported evaluation of the potential impact of the multiple conditions matrix on driver qualification and found that the proportion of drivers recommended for disqualification based on these analyses seems to be relatively low at 0.9%. If this matrix accurately categorizes risk of crash, it may potentially be an effective and feasible tool for wider implementation. This matrix is dependent on the quality of data used

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TABLE 3. Odds Ratio and 95% Confidence Interval for Associations Between Health History From Commercial Driver Medical Examination and Between BMI Categories

Variable	Underweight (BMI <18.5, $n = 424$) OR (95% CI)	Normal Weight (25 > BMI ≥18.5, $n = 13{,}465$) OR (95% CI)	Overweight (30.0 > BMI ≥ 25.0, $n = 27{,}336$) OR (95% CI)	Obese (35 > BMI ≥ 30, $n = 23{,}511$) OR (95% CI)	Morbidly Obese (BMI ≥ 35, $n = 23{,}510$) OR (95% CI)
Certification less than 2 yrs	0.92 (0.69, 1.21)	1.00 (reference)	**1.61 (1.53, 1.70)**	**2.61 (2.48, 2.75)**	**6.00 (5.69, 6.33)**
Injury/illness past 5 yrs	1.15 (0.89, 1.48)	1.00 (reference)	**1.19 (1.13, 1.26)**	**1.44 (1.36, 1.52)**	**1.75 (1.66, 1.85)**
Head/brain injuries	2.21 (0.89, 5.49)	1.00 (reference)	1.16 (0.88, 1.53)	1.02 (0.76, 1.36)	**1.32 (1.01, 1.74)**
Seizure or epilepsy	NA	1.00 (reference)	0.50 (0.24, 1.07)	0.58 (0.27, 1.24)	**0.17 (0.06, 0.53)**
Using medication	NA	1.00 (reference)	0.27 (0.06, 1.11)	1.05 (0.36, 3.07)	0.35 (0.08, 1.48)
Eye disorders	2.08 (0.97, 4.50)	1.00 (reference)	0.90 (0.72, 1.12)	0.97 (0.77, 1.21)	1.23 (0.99, 1.54)
Ear disorders	0.70 (0.22, 2.20)	1.00 (reference)	1.15 (0.95, 1.39)	1.12 (0.92, 1.36)	1.17 (0.97, 1.43)
Heart disease	1.52 (0.66, 3.50)	1.00 (reference)	**1.46 (1.21, 1.76)**	**2.11 (1.76, 2.54)**	**2.49 (2.08, 3.00)**
Heart disease medicines	NA	1.00 (reference)	**1.48 (1.10, 1.99)**	**2.04 (1.52, 2.72)**	**2.48 (1.86, 3.31)**
Heart surgery	1.34 (0.49, 3.70)	1.00 (reference)	**1.50 (1.21, 1.86)**	**2.20 (1.78, 2.71)**	**2.35 (1.90, 2.91)**
High blood pressure	0.76 (0.48, 1.21)	1.00 (reference)	**2.00 (1.85, 2.16)**	**3.61 (3.35, 3.89)**	**6.94 (6.44, 7.48)**
Using medications	0.64 (0.34, 1.22)	1.00 (reference)	**1.99 (1.81, 2.19)**	**3.22 (2.93, 3.54)**	**5.74 (5.23, 6.30)**
Muscular disease	NA	1.00 (reference)	0.66 (0.30, 1.41)	0.82 (0.38, 1.75)	0.47 (0.20, 1.14)
Lung disease	**1.81 (1.10, 2.99)**	1.00 (reference)	0.94 (0.81, 1.08)	1.09 (0.95, 1.26)	**1.37 (1.19, 1.57)**
Shortness of breath	**3.26 (1.74, 6.11)**	1.00 (reference)	**0.69 (0.55, 0.88)**	0.97 (0.77, 1.22)	**1.47 (1.19, 1.83)**
Kidney disease	1.23 (0.17, 9.09)	1.00 (reference)	0.96 (0.61, 1.50)	1.16 (0.74, 1.82)	1.25 (0.80, 1.96)
Liver disease	NA	1.00 (reference)	0.85 (0.54, 1.36)	0.81 (0.50, 1.32)	0.82 (0.50, 1.35)
Digestive problems	1.79 (0.87, 3.68)	1.00 (reference)	**1.22 (1.01, 1.48)**	**1.57 (1.30, 1.89)**	**1.76 (1.46, 2.12)**
Diabetes mellitus	1.02 (0.50, 2.08)	1.00 (reference)	**2.34 (2.06, 2.66)**	**4.15 (3.66, 4.71)**	**7.99 (7.06, 9.05)**
Controlled with diet	1.30 (0.57, 2.97)	1.00 (reference)	**2.33 (1.97, 2.75)**	**3.96 (3.36, 4.66)**	**7.47 (6.37, 8.77)**
Controlled with insulin	NA	1.00 (reference)	1.22 (0.39, 3.84)	1.31 (0.41, 4.18)	2.19 (0.73, 6.60)
Controlled with pills	0.65 (0.24, 1.77)	1.00 (reference)	**2.42 (2.09, 2.80)**	**4.26 (3.69, 4.91)**	**8.30 (7.21, 9.54)**
Nervous disorders	**2.53 (1.45, 4.39)**	1.00 (reference)	**1.31 (1.10, 1.56)**	**1.56 (1.31, 1.85)**	**1.86 (1.57, 2.20)**
Using medications	2.04 (0.89, 4.68)	1.00 (reference)	**1.37 (1.08, 1.74)**	**1.68 (1.32, 2.12)**	**2.02 (1.60, 2.54)**
Altered consciousness	NA	1.00 (reference)	0.72 (0.36, 1.44)	0.84 (0.42, 1.69)	0.80 (0.39, 1.63)
Fainting/dizziness	2.99 (0.39, 23.25)	1.00 (reference)	0.99 (0.48, 2.02)	1.20 (0.59, 2.44)	1.34 (0.66, 2.71)
Sleep disorders	**3.80 (1.35, 10.73)**	1.00 (reference)	**2.29 (1.60, 3.28)**	**5.49 (3.89, 7.73)**	**28.59 (20.53, 39.79)**
Stroke or paralysis	NA	1.00 (reference)	0.67 (0.37, 1.22)	1.21 (0.70, 2.10)	1.24 (0.71, 2.19)
Missing extremities	1.45 (0.59, 3.58)	1.00 (reference)	1.05 (0.85, 1.30)	1.08 (0.87, 1.35)	1.08 (0.86, 1.35)
Spinal injury or disease	0.89 (0.33, 2.41)	1.00 (reference)	1.18 (0.97, 1.42)	**1.28 (1.06, 1.55)**	**1.34 (1.10, 1.62)**
Chronic low back pain	2.08 (0.84, 5.15)	1.00 (reference)	1.20 (0.92, 1.56)	**1.30 (1.00, 1.70)**	**1.36 (1.05, 1.77)**
Frequent alcohol use	NA	1.00 (reference)	1.20 (0.78, 1.87)	1.05 (0.66, 1.66)	0.90 (0.56, 1.45)
Habit forming/narcotic drugs	1.29 (0.17, 9.57)	1.00 (reference)	0.59 (0.34, 1.04)	1.11 (0.67, 1.84)	0.70 (0.40, 1.21)
Monocular vision	2.75 (0.99, 7.66)	1.00 (reference)	0.89 (0.63, 1.26)	**0.66 (0.45, 0.98)**	0.73 (0.50, 1.06)
Requires vision correction	**1.26 (1.03, 1.54)**	1.00 (reference)	1.02 (0.98, 1.06)	**1.08 (1.03, 1.13)**	**1.30 (1.24, 1.35)**
Recognize colors	NA	1.00 (reference)	1.17 (0.68, 1.99)	1.11 (0.65, 1.92)	0.92 (0.54, 1.55)

BMI, body mass index; CI, confidence interval; OR, odds ratio; NA, not available.

to create the matrix, as well as the application and generalizability of the matrix among medical examiners. Yet, the relationships between these risk factors and subsequent crash data have not been prospectively evaluated and are the focus of subsequent work.

There are questions about examiners and regulations placing undue attention to obese drivers. These data demonstrate that there are meaningful relationships between obesity and other conditions within this population. Anecdotally, obese drivers feel that they are unjustly treated because of their obesity. Although it is well accepted that there are many concomitant disease states that occur in conjunction with obesity, this study is the first to quantify these relationships within a safety sensitive population. These data calculate the association between obesity and with multiple conditions that propel drivers into limited certification or disqualification categories.

Although this study has highlighted some health factors associated with a high BMI, the mechanism whereby obesity can increase risk for crashes is not definitively known. The association of BMI and sleep disorders is well documented, and related on-road safety impacts have been studied. For example, obese CMV drivers report falling asleep unintentionally more often than normal or overweight CMV drivers, and higher rates of sleep apnea among the obese have been found.[28–31] Thus, the relationships between BMI and disqualifying factors may represent modifiable means to prevent preclusion of driving and crash probability, through the reduction in BMI. Although studies have reported and assessed relationships between

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TABLE 4. Relationships Between BMI Categories and Number of Relative Disqualifying Conditions From Commercial Driver Medical Examination With *P* Value for Differences Between BMI Categories

Number of Conditions*	Underweight BMI <18.5 ($n = 424$)		Normal Weight 25 > BMI ≥ 18.5 ($n = 13,465$)		Overweight 30.0 > BMI ≥ 25.0 ($n = 27,336$)		Obese 35 > BMI ≥ 30 ($n = 23,511$)		Morbidly Obese BMI ≥ 35 ($n = 23,510$)		Total ($n = 88,246$)		*P*
0	356	84.0%	11,051	82.1%	19,781	72.4%	14,951	63.6%	12,461	53.0%	58,600	66.4%	<0.0001
1	50	11.8%	2,028	15.1%	6,038	22.1%	6,499	27.6%	7,620	32.4%	22,235	25.2%	
2	17	4.0%	340	2.5%	1,323	4.8%	1,737	7.4%	2,719	11.6%	6,136	7.0%	
3	1	0.2%	41	0.3%	177	0.6%	274	1.2%	603	2.6%	1,096	1.2%	
4	0	0.0%	5	0.0%	16	0.1%	41	0.2%	97	0.4%	159	0.2%	
5	0	0.0%	0	0.0%	1	0.0%	9	0.0%	9	0.0%	19	0.0%	
6	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.0%	1	0.0%	

*Body mass index >35 kg/m^2 excluded from criteria.
BMI, body mass index.

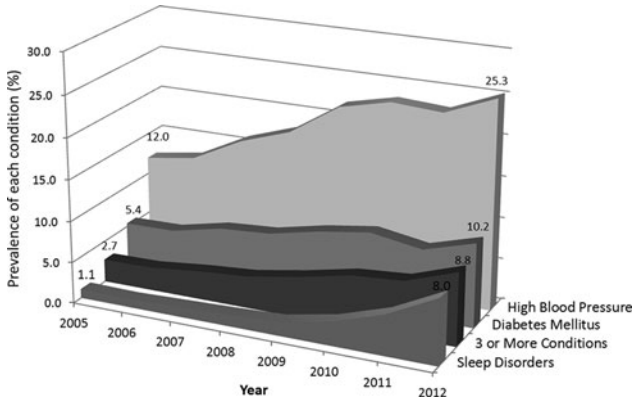

FIGURE 2. Change in prevalence of select conditions among study population from 2005 through 2012.

health and crashes, many of the studies are small and have potential selection and information biases. One study that reported obese commercial CMV drivers (BMI ≥30 kg/m^2) have a significantly higher crash rate (more than two times) than nonobese commercial CMV drivers had a limited sample size that necessitated aggregating all BMI measures (BMI ≥30 kg/m^2) into one category.[19] By disaggregating BMI categories from a much larger data set, this study is able to better delineate relationships between BMI categories and other factors. Although many of the published studies on CMV driver health focus on the relationship between obesity and sleep apnea, data from this study demonstrate that there are many disease states, including hypertension, cardiovascular disease, diabetes mellitus, psychological diseases, spinal injuries/diseases, and narcotic or habit forming drug use, that seem to be related to obesity in truck drivers. These disease states may play a meaningful role in crashes, and the relationship between these disorders, medications, and interactions among them in association with crash risk is an area requiring further study.

Qualitatively, there is likely underreporting and underdiagnosis of many of these factors, due to the probability that a driver may perceive a lower probability of certification and thus maintenance of livelihood. These underreporting and underdiagnosis are likely not random in relation to BMI, with obese drivers being more likely to underreport at least some disorders, particularly for the multiple conditions listed in Table 1. Given this, it is likely that the true relationships between increasing BMI and these other factors are likely stronger than those demonstrated by these analyses.

Strengths of this study include the large sample size and nationwide representation. Because of the relative rarity heart surgery, heart disease, nervous disorders, diabetes mellitus, high cholesterol, and even hypertension, few studies have the ability to address relationships between these factors and outcomes. This study's large sample size allows for adequate statistical power when evaluating relationships with these conditions to outcomes. Age, sex, and other measures are reasonably similar to other reports of commercial CMV drivers.[1,15,27,29,32–35] This study provides an objective approach by utilizing CDME data and provides a much deeper analysis of a wide range of health attributes. This study also has the ability to estimate the impacts of the multiple conditions matrix on the workforce absent reversing disorders. It is also the first study reporting results of serial CDMEs.

The most important limitation is likely that the initial CDME data are cross-sectional and therefore cannot demonstrate temporality. There is a possibility of self-selection bias; however, we believe any influence of selection bias(es) should likely be minor. Nevertheless, we believe there is likely an additional and stronger selection bias regarding who stays with a company for a second consecutive CDME that may have impacted the results. Additional evaluations of potential relationships with other factors (eg, type of driver, type of examiner, and workloads) were not available. The CDME also combines multiple specific diagnoses and conditions into some categories (eg, sleep disorder and nervous disease). Unfortunately, we cannot differentiate between different diagnoses or conditions under this large umbrella and therefore cannot assess relationships between BMI categories and individual conditions.

Further study on relationships between both BMI and specific factors within the CDME and their temporal relationship with subsequent crashes is needed to identify attributable proportions and relationships between these factors. An interventional study to impact the relationship between BMI, CDME factors, and reduction of crashes is also needed.

CONCLUSIONS

Most CMV drivers in this large population are obese (53.3%), and 26.6% have a BMI more than 35.0 kg/m^2. There are many significant and clinically meaningful relationships between CDME elements and BMI categories that include cardiovascular issues, diabetes mellitus, sleep disorders, spinal injuries or disease, lung disease, shortness of breath, digestive problems, illness or injuries in the past 5 years, and requiring vision correction. Furthermore, there

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are strong relationships between BMI categories and relative disqualifying conditions, with a meaningful and statistical increase in disqualifying conditions as BMI increases. This suggests that impacts of obesity are numerous and potentially beyond those commonly recognized. This study also found that obesity was strongly linked to recommended CMV driving disqualification using the Medical Review Board multiple conditions matrix.

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