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Obesity is associated with the future risk of heavy truck crashes among newly recruited commercial drivers

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ABSTRACT

This study estimates the dose–response relationship between body mass index (BMI) and crash risk in operators of heavy commercial motor vehicles. Intake data were collected during the first two weeks of instruction from 744 new truck drivers training for their commercial driver's licenses at a school operated by the cooperating trucking firm. Drivers were then followed prospectively on the job using the firm's operational data for two years, or until employment separation, whichever came first. Multivariate Poisson regression and Cox proportional hazards models were used to estimate the relationship between crash risk and BMI, controlling for demographic characteristics and for variations in the exposure to risks on the road. Results from the Poisson regression, which used cumulative miles driven as an exposure control, indicated that compared to normal BMI ($18.5 < BMI < 25$) the risk ratio (RR) for all crashes was significantly higher for drivers in the combined obesity Classes II and III: RR = 1.55 (95% CI 1.24–1.94). Similarly, the multivariate Cox proportional hazard model (controlling for miles and job type on a week-by-week basis) showed that crash risk was significantly higher compared to normal BMI for the same combined obesity Classes II and III: RR = 1.54 (95% CI 1.13–2.10). The results of this prospective study establish an association between obesity and crash risk and have important implications for driver health and public safety.

1. Introduction

It is well known that the prevalence of obesity among U.S. adults has more than doubled in recent decades (Flegal et al., 2010). Similar trends have been documented worldwide, and such increases are expected to continue (WHO, 2000; Finucane et al., 2011). Additionally, because of obesity's contribution to diabetes mellitus (Eckel et al., 2011), cardiovascular disease, and certain cancers, the obesity epidemic's projected negative public health consequences on morbidity and mortality trends are frequently discussed (Calle et al., 2003; Berrington de Gonzalez et al., 2010).

On the other hand, the potential impact of increasing obesity on public safety has received considerably less attention. Because of robust associations with obstructive sleep apnea (OSA), excessive daytime sleepiness (EDS), and fatigue (Vgontzas et al., 1998; Teran-Santos et al., 1999; Philip, 2005; Vgontzas, 2008b) obesity could present significant risks during the performance of complex tasks such as driving trucks, piloting aircraft, operating public transit vehicles, and similar operational activities found in several transportation modes that require constant attention and vigilance (Dinges et al., 1997; Dagan et al., 2006; Cohen et al., 2010). If this hypothesis were true, even a small increase in risk would have a major impact on the population-attributable risk, given the frequent role of fatigue in crashes and the high prevalence of obesity (Dixon et al., 2007). For example, the Institute of Medicine (IOM) has estimated that nearly 20% of all serious injuries caused by motor vehicle crashes are related to drowsy driving (Garbarino et al., 2001). Similarly, the National Transportation Safety Board (NTSB) concluded that more than 30% of fatal-to-the-driver truck crashes are fatigue related (NTSB, 1999). Moreover, obesity has been reported to be present in as many as 50% of commercial drivers (Gurubhagavatula, 2010). Thus, any additional risk due to obesity

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would have important policy consequences for the transportation industry and society at large.

One area that has received increasing interest from government regulators and investigators in occupational and sleep medicine is the association of obesity with OSA (Pack et al., 2006; Tregear et al., 2009). OSA is common among commercial drivers; with prevalence estimated as high as 17–28% (Pack et al., 2002; Talmage et al., 2008; Parks et al., 2009); and a number of BMI-based driver screening strategies have been proposed (Gurubhagavatula et al., 2004; Hartenbaum et al., 2006). Working conditions in firms operating in the "truckload" (TL) segment of for-hire motor carriage (Burks et al., 2010), like the firm cooperating in this study, are particularly conducive to irregular rest and significant and persistent levels of driver fatigue. Driving for a TL firm involves serving different customers in different locations spread across the country, with varying trip origins and destinations, changing congestion and weather conditions, restrictions on behavior due to hours of service, route, and fueling rules, limited and uncertain time at home, and the expectation that drivers on the road live in their sleeper bunks (Burks et al., 2008). Together these factors generate pressure towards long work hours per day and per week that come at varying times of the day and night, and towards insufficient and irregular sleep. In fact, it is the ability of an individual to effectively manage his or her work life under these conditions that is the largest single predictor of success in this specific occupation (Burks, 2009; Burks et al., 2009). However, while studies in the general population have documented a two to seven-fold increase in motor vehicle accidents among persons with untreated OSA (Teran-Santos et al., 1999; Komada et al., 2009; Tregear et al., 2009), these results have not been replicated reliably in commercial truckers (Pack et al., 2002).

A less appreciated, but equally important concern is that the obesity epidemic may be an important underlying cause of an increasing prevalence of fatigue and excessive daytime sleepiness (EDS) in the general population (Vgontzas, 2008a,b). Accumulating evidence in the field supports the notion that through inflammatory pathways and mechanisms, visceral adiposity, insulin resistance and neuro-hormonal signaling, obesity plays a major role in the pathogenesis of sleep apnea as well as excessive daytime sleepiness. Although EDS is one of the main symptoms of OSA in clinical practice, obese patients can also present with significant EDS in the absence of OSA (Vgontzas et al., 1998).

Finally, obesity is connected with several other medical conditions, such as degenerative arthritis and body habitus-imposed mobility limitations (Cranney et al., 2005), which may create further distinct links between BMI and driving performance. Therefore, in this prospective study we examined the risk of truck crashes as a function of BMI among newly recruited professional drivers, statistically controlling for relevant factors that affect on-the-job exposure to accident risk.

2. Materials and methods

2.1. Study participants and data collection

Firms of the type cooperating with the present study, truckload for-hire motor carriers, historically have a significantly higher turnover rate than trucking firms of other types, reported by the American Trucking Associations to average more than 100% per year until the recent economic recession (Economic and Statistics Group, 2007; Watson, 2009). Thus a significant fraction of drivers in this segment of the industry are always new hires, which makes new-to-the-industry trainees a relevant study population.

One thousand sixty-five new driver-trainees from a large nationwide trucking firm were eligible for the study over the period from December 2005 through August 2006, which was conducted as part of the Truckers & Turnover Project, a larger ongoing behavioral economics research program (Burks et al., 2008). The study protocol was approved by the IRB of the University of Minnesota. Data from participants were collected at a school operated by the cooperating firm in the middle of a two-week residential training program. All participating drivers completed an informed consent process and were compensated for their time; there was 91% participation rate among eligible trainees. The informed consent process made it clear to subjects that data collected were going only to academic researchers authorized by the University of Minnesota, and would never be shared with their employer, which we believe improved the likelihood of honest responses.

Of the 952 drivers that completed training and spent at least one week on the road, we have the BMI values for 744 participants. All subjects who were asked provided this information; the reduction in number is due to the fact that questions about height and weight were only added to the intake data collection some time after initiation. Drivers completing training were then followed prospectively on the job using the firm's human resource and operational data for two years, or until an employment separation, whichever came first (further details on the data collection may be found in Burks et al., 2008). Drivers self-reported their heights and weights during initial intake via a computerized demographic survey that each driver completed privately. Heights were self-reported to the nearest inch ±0.5 in. between 5 feet, 0 in. and 6 feet, 6 in.; and weights were self-reported to the nearest pound ±10 pounds between 100 and 350 pounds by selecting from height and weight category choices. Body mass index (BMI) values were then calculated using the mid-point of each category choice and the standard formula: $\text{BMI} = (\text{weight (lbs)} \times 703.1)/[\text{Height (in.)}]^2$. For example, a driver who self-reported his height as 5 feet and 8–9 in. and weight as between 160 and 180 pounds was assigned a BMI of $(170 \times 703.1)/[68.5]^2$ or 25.5. Because most self-reports err on the side of taller heights and lower weights, this methodology for estimating BMI is quite conservative and tends to underestimate BMI.[1] We defined BMI categories as per the World Health Organization (WHO): (Underweight = BMI < 18.5; Normal = 18.5 < BMI < 25.0; Overweight = 25 ≤ BMI < 30; Obese Class I = 30 ≤ BMI < 35; Obese Class II = 35 ≤ BMI < 40; Obese Class III = BMI ≥ 40 (further details on data collection may be found in Burks et al., 2008).

2.2. Driving exposure and occupational covariates

A significant advantage in using internal administrative data from a firm is that we have information on relevant occupational covariates that capture how the exposure to risk varies: miles driven, job type (which identifies duties and working conditions) and home terminal location for each participant. These data were collected on a weekly basis from the firm's records for each participant until the end of the follow-up period in August, 2008 and are cumulated to a single summary record for each driver for our initial analysis, while being retained in a driver-week form for our most sophisticated statistical models.

2.3. Crash outcomes assessment

A second significant advantage of working with a large trucking firm is that we have information regarding all accidents, including

[1] The use of categories may reduce the frequency of misreports by making the correct category selection more likely. However, this method still may have a downward bias. When a subject picks the next lower weight or next higher height category the use of the category midpoint slightly exaggerates the misreport, and because weight is in the numerator and height in the denominator of the BMI formula, both exaggerations cause underestimation.