Evidence Report

Fatigue and Motorcoach/Bus Driver Safety

Presented to the Federal Motor Carrier Safety Administration

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Prepared by

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Evidence reports are sent to the Federal Motor Carrier Safety Administration's (FMCSA) Medical Review Board (MRB) and Medical Expert Panels (MEP). The MRB and MEP make recommendations on medical topics of concern to the FMCSA.

The FMCSA will consider all MRB and MEP recommendations, however, all proposed changes to current standards and guidance (guidelines) will be subject to public notice and comment and relevant rulemaking processes.

Policy Statement

This report was prepared by MANILA Consulting Group, Inc., under contract GS-10F-0177N/DTMC75-06-F-00039, with the Department of Transportation's Federal Motor Carrier Safety Administration. The purpose of this evidence report is to provide information on the current state of knowledge on this topic. It is not intended as instruction for medical practice, nor for making decisions on individual patients.

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Executive Summary

More than 124,000 large trucks and buses were involved in crashes on America's roadways in 2009, resulting in 3,619 deaths and 75,141 injuries. The effects of non-pathologic or acute fatigue can impair the ability of professional drivers, who drive long distances for hours at a time, to drive effectively and safely. Although fatigue has been well researched, its effect on transportation drivers, in particular motorcoach drivers, is of particular interest. Motorcoach drivers face extended workdays that require non-driving duties, intermittent non-working periods, and lengthy contact with passengers. The Federal Motor Carrier Safety Administration (FMCSA) – tasked with preventing related injuries and fatalities related to trucks, busses, motorcoaches and other commercial vehicles in the United States – seeks to identify motorcoach drivers' risk for crash as a result of acute fatigue and given the differences between motorcoach drivers and interstate truck drivers, all of which are explored in this evidence review.

Purpose and Scope of Evidence Report

This purpose of this report is to assess and characterize the relationship between crash and fatigue in generally healthy motorcoach drivers. Non-pathologic fatigue can be caused by factors such as insufficient sleep, disrupted circadian cycles, stress, and monotony. Fatigue or sleepiness caused by medical or sleep conditions is outside the scope of this report and has been previously assessed by the Federal Motor Carrier Safety Administration (FMCSA) in other evidence reports.

This evidence report addresses four key questions developed by the FMCSA to inform evaluation of current medical examination guidelines:

Key Question 1: What impact does non-pathologic fatigue have on crash incidence and driving ability?

Key Question 2: How much rest does a fatigued professional driver need to resume driving unimpaired?

Key Question 3: How do motorcoach drivers differ from truck drivers in terms of the following attributes:

A. Demographics (gender, age, race, etc.)?
B. Job function (pre-trip preparations, roads and distances travelled, opportunities for rest, etc.)?
C. Work environment (interactions with passengers, cabin ergonomics, schedules, shift cycles, etc.)?
D. Health-related behaviors and disease characteristics (body mass index, caffeine and alcohol use, depression, cancer, etc.)?

Key Question 4: Do identified differences between motorcoach and truck drivers increase (or decrease) the risks for acute non-pathologic fatigue?

The first two key questions assess the impact of non-pathologic fatigue on crash incidence and driving ability in motorcoach drivers and how much rest motorcoach drivers need to recover from this type of fatigue, also referred to as acute fatigue. Evidence on optimal shift and rest patterns also are identified.

Key Question 3 identifies quantitative differences between motorcoach and truck drivers in terms of demographics, job functions, work environments, and health-related behaviors and disease characteristics. Key Question 4 assesses whether the differences identified in Key Question 3 increase or decrease the risk of non-pathologic fatigue in motorcoach drivers. To inform assessment of hours-of-service rules for motorcoach drivers, the Agency wants to identify differences between interstate truck drivers, in general, and motorcoach drivers.

Identification of Evidence

We identified publications using a multistage process: We (1) searched the literature using electronic and manual methods; (2) applied retrieval criteria to titles and abstracts of identified studies to select articles for review; and (3) applied full inclusion criteria to full-length articles to determine which to include. Retrieval and inclusion criteria were designed with the FMCSA to ensure systematic selection of relevant studies that address the key questions and outcomes of interest.

Rating the Strength of Evidence

We critically appraised the risk of bias of individual studies using standard instruments to inform the quality of the overall evidence base and then considered this along with consistency, robustness, and amount of evidence to render strength of evidence ratings. The strength of evidence ratings are defined in Table 1.

Table 1. Strength-of-Evidence Ratings

Strength of Evidence	Interpretation
Strong	Evidence supporting the conclusion is convincing. It is highly unlikely that new evidence will lead to a change in this conclusion.
Moderate	Evidence supporting the conclusion is somewhat convincing. There is a small chance that new evidence will overturn or strengthen our conclusion. Regular monitoring of the relevant literature for moderate-strength conclusions is recommended.
Minimally acceptable	Although some evidence exists to support the conclusion, this evidence is tentative and perishable. There is a reasonable chance that new evidence will either overturn or strengthen our conclusions. Frequent monitoring of the relevant literature is recommended.
Insufficient	Although some evidence exists, the evidence is insufficient to warrant drawing an evidence-based conclusion. Frequent monitoring of the relevant literature is recommended.

Findings

Key Question 1: What impact does non-pathologic fatigue have on crash incidence and driving ability?

A. Crash

We examined the impact of non-pathologic fatigue on real-world crash by summarizing important previous work, assessing the literature, and highlighting gaps in the information. Previous work, including a 2009 FMCSA-commissioned systematic review, points to an association between fatigue and/or sleepiness and crash. However, in these previous works, drivers were not selected for healthfulness, and the influence of sleep disorders or health issues on these statistics is unknown. To address gaps in the identified previous work, we conducted two new assessments. First, we investigated the association between crash and fatigue or sleepiness in healthy drivers only. Then, we assessed the association between driving patterns, which can be fatiguing, and crash in professional drivers.

Crash and Fatigue or Sleepiness in Healthy Drivers

This analysis was intended to provide information on the impact of non-pathologic fatigue on crash, and to be free from the potentially confounding influence of fatigue or sleepiness consequent to a health or medical issue. We searched for relevant literature on fatigue or sleepiness and crash in healthy individuals only. No studies assessing the impact of fatigue or sleepiness on healthy drivers on crash incidence were identified.

Crash and Driving Patterns in Other Commercial Motor Vehicle Drivers

We also assessed the influence of driving patterns on crash among professional drivers. Demanding driving patterns could potentially fatigue drivers. Driving patterns for the purposes of this assessment include anything related to driving schedule, such as time-of-day driving, hours driven per day and week, and duration of breaks and rest.

Motorcoach Drivers

No studies that assessed driving patterns and motorcoach drivers were identified.

Other Commercial Motor Vehicle Drivers

Evidence primarily on truck drivers suggests that the incidence of crash increases after 5 or 6 hours of driving and continues to increase through the end of driving time at 8 to 11 hours. *(Strength of Evidence: Moderate)* Kaneko et al., 1991[1], found crash risk was highest during the first hour of driving, which was not replicated in other studies. After this initial elevated risk, the crash risk rose after hour 5 driving. Park et al., 2005[2], similarly found crash risk rose after the first 5 hours of continuous driving, and Jovanis et al., 2011[3, 4], found it increased after 6 hours.

After the first 5 to 7 hours of driving, studies generally found the crash incidence continued to rise. Park et al. found crash incidence rose significantly after 5 hours of continuous driving, as did Kaneko et al. Jovanis et al., 2011[3], found that in less-than-truckload trucks, crash incidence increased after the 6th hour of driving, and in truckload loads it increased after the 7th.

With one exception, the rest of the studies found greater crash incidence with even longer driving duration. Park et al. reported that crash incidence did not continue to significantly increase during continuous driving hours 5 through 10. Jones and Stein, 1987[5], found drivers who drove more than 8 hours were more likely to be in a multiple-car accident and had a higher crash incidence than drivers driving only 2 hours. Kaneko et al. noted, though, that it found crash risk continued to increase up to the 9th hour of continuous driving. McCartt et al., 1998[6], found that drivers who drove more than 10 consecutive hours were more likely to have been in a crash in the preceding 5 years. Jovanis et al. found that crash increased up to the 11th hour of driving, with the highest odds of crash at the 11th hour.

Crash incidence is generally highest during overnight and early morning hours, and increased in the afternoon. *(Strength of Evidence: Minimally Acceptable)* Nine studies assessed the relative frequency of crash by time of day, as described in the following text. Six studies (Hickman et al., 2005[7]; Park et al. 2005 [2]Jones and Stein, 1987[5]; Jovanis et al., 2011[8]; Massie et al., 1997[9]; and NTSB, 1996[10]) observed greater crash incidence in overnight to early morning hours, generally between midnight and 8 a.m. (with some variation in time frame assessed among studies). Massie et al. also observed another peak in crash between 3 p.m. and 5 p.m. Two studies had contrary findings. Kaneko at al. observed higher crash incidence among drivers who operated their vehicles in the afternoon and evening, and suggested this could be due to greater traffic congestion during those time. Sando et al.[11] found transit bus crash incidence was lowest between midnight and 4 a.m. and highest between 1 p.m. and 7 p.m. It attributed this to greater routes and risk exposure in the afternoon and evening.

B. Driving Ability

In this section, we examine the impact of non-pathologic fatigue or sleepiness on driving performance, measured by real-world driving and driving simulator studies. Real-word driving studies measure driving ability using special vehicles with instruments that measure driving performance and/or an expert passenger who assesses driving performance, or video monitoring or driver and vehicle. Driving simulator studies collect driving ability measures in a computer-generated driving environment.

Although this question is intended to assess driving ability in healthy drivers, we did not exclude drivers for whom health status was not reported, because previous FMCSA-supported systematic review work does not address the impact of fatigue or sleepiness on driving ability (as was the case for crash). However, we did exclude drivers who clearly had a health or sleep issue that could impact driving, such as obstructive sleep apnea.

Motorcoach Drivers

No included studies address the role of non-pathologic fatigue on driving ability in motorcoach drivers.

Other Commercial Motor Vehicle Drivers

Evidence suggests critical event rates increase over 11-hour driving shifts, which represented driving task-related fatigue for the purpose of this analysis. *(Strength of Evidence: Minimally Acceptable)* Two naturalistic studies of commercial truck drivers, the Drowsy Driver Warning System Study (n=99)[12, 13] and the Naturalistic Truck Driving Study (n=97)[14, 15] assessed the critical event rate (events per opportunity) over 11 hours of driving. The Drowsy Driver Warning System Study found that the rate was statistically significantly higher at hours 2 through 11, compared to the first hour of driving. The Naturalistic Truck Driving Study found the safety critical event increased by the hour, and the authors concluded this represented a time-on-task effect. Neither study found a statistically significant increase in event rate between the 10^{th} and 11^{th} hour.

No other specific conclusions are possible because each of the studies report different outcomes for the same general area of fatigue assessment; however, in general, the studies suggest fatigue impairs driving ability.

Non-professional Drivers

Evidence suggests insufficient sleep leads to greater incidence of simulated crash *(Strength of Evidence: Moderate)*, and that it is associated with decreased ability to drive within lane *(Strength of Evidence: Strong)*. Other measures of driving ability were addressed by fewer studies with less consistent findings; this evidence was insufficient to support evidence-based conclusions.

Three studies assessed the influence of insufficient sleep on simulated crash in healthy adults, and all found that with less sleep or longer duration since last sleep, crash was more common. Baulk et al., 2008[16], kept 15 adults up for 26 hours of supervised wakefulness, and they had only one or two collisions per simulated drive except for between hours 24 and 26, when they had 25. The other two studies subjected the volunteers to sleep restriction and then measured crash frequency during driving simulation at the afternoon circadian nadir, starting at 2 p.m. Peters et al., 1999[17], found the mean crash incidence was higher after only 4 hours in bed the previous night than after non-deprived sleep the preceding day. Vakulin et al., 2007[18], and colleagues found that significantly more of their 21 drivers crashed after 4 hours in bed than after 8.5 hours in bed.

Seven studies assessed the relationship between insufficient sleep and lane deviation in healthy adult volunteers. Insufficient sleep was experimentally induced by either prolonging wakefulness or assigning reduced time in bed. These studies consistently found that increased wakefulness or time in bed restricted to less than four hours was associated with greater lane deviation.

Among studies that kept drivers up for prolonged wakefulness and repeatedly measured lane deviation, all found deterioration. Baulk et al. kept 15 adults awake for 26 hours and found that lane drifting increased significantly with duration of wakefulness and was higher at each time the drive was repeated during increasingly extended wakefulness. Matthews et al., kept 14 young men awake for 22 hours and found that during 10-minute drives taken between 2 and 22 hours of wakefulness, lane drifting was not significantly different.[19] However, the number of times the center of the car left the road or struck a vehicle it was passing significantly increased over time. Arnedt et al. measured performance over 30-minute drives at 2:30 a.m., 5 a.m., and 7:30 a.m. after a normal day among 29 young healthy college students, and found that with increased time awake, lane deviation increased at each session, and increased faster during later sessions.[20].

The four studies that restricted time in bed to four hours or less found impairment in lane tracking, which was most pronounced at durations of time in bed of less than four hours. Philip et al., assigned 14 healthy young men to 2 hours in bed one night and 8 another night, finding that during real or simulated drives of over 100 miles repeated throughout the following day, there were more inappropriate line crossings after 2 hours in bed but that performance did not deteriorate throughout the day for either group.[21] Park et al., assigned 14 healthy young adults to 0, 4, and 8 hours of sleep before a 60-minute simulation drive and found lane deviation was worse when the participants had no sleep, but it was not significantly different when they had 4 hours compared to 8 hours.[22] Otmani et al., tested healthy men in a 90-minute simulation between 2 p.m. and 4 p.m. after no sleep deprivation or only 4 hours in bed. They did not find a significant difference between groups at any one time point, but did find a significant difference overall in a repeated measures analysis.[23] Lenne et al., 1998[24], compared performance after sleep deprivation or normal night's sleep in 24 college students at 8 a.m., 11 a.m., 2 p.m., 5 p.m., and 8 p.m., and found that sleep-deprived drivers drove more laterally, but within acceptable boundaries. They noted that changes during the day or within sessions were not significant.

Five of the studies described above, Matthews et al., [19], Arnedt et al.[20], Otmani et al., [23], Park et al.[22], and Lenne et al.[24], also assessed lane deviation variability, defined as the standard deviation of lane position. All found that experimentally induced insufficient sleep significantly increased lane deviation variability.

Key Question 2: How much rest does a fatigued professional driver need to resume driving unimpaired?

The intent of this key question was to determine the optimal rest duration and pattern required for a fatigued motorcoach driver to adequately recover functioning to a level consistent with safe driving. For this question, we define the "amount of rest" as any period of time spent not working. This period may, or may not, include sleep. Rest could take place during a shift break, before a shift (eg, overnight sleep), or between shifts (eg, reset). Breaks could be planned or taken in response to fatigue. In addition to coach drivers, commercial truck and bus drivers were assessed.

Motorcoach Drivers

No studies were identified that addressed rest and functional recovery in motorcoach drivers.

Other Commercial Motor Vehicle Drivers

Evidence suggests resting or napping for 30 minutes during a work break may reduce the incidence of crash, near crash, or other safety critical events, but there is an insufficient quantity of evidence from which to determine what the minimal duration is, and other studies inconsistently suggest that napping for any duration does not improve feelings of fatigue or sleepiness. *(Strength of Evidence: Minimally Acceptable)*

Perez-Chada, 2005[25], and the Naturalistic Truck Driving Study, 2011[26], assessed the impact of rest during shift on driving function. Perez-Chada compared the incidence of safety critical events in long-haul truck drivers who did and did not leave the road to take a 30- to 40-minute rest break in response to sleepiness, and found that those who napped had a significantly lower incidence of crash or near crash. In the Naturalistic Truck Driving Study, safety critical event incidence was compared in truck drivers before and after a 30-minute rest break, during which drivers did not work and did not necessarily sleep. The study found the safety critical event incidence was 28 percent lower after the break. Boivin et al.[27], which compared self-reported fatigue among truck drivers based upon their reported duration and frequency of rest, did not find an association between fatigue and time napping on or after shifts. Wylie et al., 1998[28], compared objective measures of sleepiness (eg, droopy eyelids, repeated blinks, as recorded on video and reviewed by investigators) and self-reported sleepiness in truck drivers before and after they took naps. The authors reported wide variation within and between drivers in signs and symptoms of sleepiness before and after naps. Their analysis could not link duration of nap sleep time with post-rest alertness; the authors postulated this might be due to the wide variation among individuals.

Evidence suggests a minimum of 4 to 6.7 hours is needed in the 24 hours before driving, and that at least 8 to 12 hours is needed in the 48 hours before driving to function well. One study emphasized that sleep in the 24 hours prior to shift start, as well as total sleep during the 48 hours before, were important for function. *(Strength of Evidence: Minimally Acceptable)*

Four studies, listed below, addressed the association between duration of sleep before shift and crash, safety critical event, or driving-related psychomotor vigilance. Two of those studies assessed crash. Dorrian and Dawson,[29], analyzed the amount of sleep before a crash among truck drivers with fatigue-related crash and those with crash due to other causes (eg, weather, speeding), finding that crash was less likely to be due to fatigue if the driver slept more than 6.5 hours in the preceding 24 hours *and* at least 8 hours total in the preceding 48 hours. The authors emphasized that these factors are most predictive of fatigue-related crash when considered together. Hertz et al.[30], compared fatal crash incidence in tractor-trailer drivers, who slept in two four-hour shifts in the sleeper berth, to those who slept eight hours continuously, finding the adjusted odds ratio of fatal crash was about three times higher in the broken rest group.

Hanowski et al.[31] assessed safety critical events, including crash and near-crash. The study reported the mean duration of sleep the night before a critical incident during the 10th or 11th hour of driving was 5.28 (SD 2.03) hours. The overall study period mean was 6.63 (SD 1.47) hours. The findings were similar whether or not drivers were at fault.

The remaining study addressing function assessed driving-related psychomotor vigilance. Belenky et al. [32], and Balkin et al. [33], conducted an experimental laboratory study in which truck and bus drivers were assigned to three, five, seven, or nine hours in bed overnight for a week, and the duration of sleep was physiologically monitored. Psychomotor vigilance task performance declined for all groups except the nine-hour group. Impairment was seen starting on day two for the three-hour group, and starting on day three for the five-hour group. The sleep-deprived groups then were assigned to a three-day recovery period with eight-hour nights, and psychomotor task recovery was observed for the three-hour group on the first day, but not at all for the five-hour group. The study authors concluded that at least four hours of sleep per night is required to maintain daytime alertness and performance.

Two studies assessed pre-shift rest or sleep and sleepiness. Belenky et al. [32], and Balkin et al., [33], described above, also reported objective sleepiness outcomes (ie, time to fall asleep at night) and self-reported sleepiness. They found the group assigned to three hours of rest in bed per night reported statistically significantly greater sleepiness after the first night, but the groups with five, seven, or nine hours in bed per night did not. They reported the time to fall asleep significantly shortened for the three- and five-hour groups, and that recovery on this outcome was not observed after the participants were reassigned to the three-day recovery period with eight hours of bedtime per night. No changes were observed in the seven- and nine-hour rest groups throughout the study. As noted above, the authors concluded at least four hours of sleep per night is necessary to maintain alertness and performance.

Barr et al.,[34], found that drivers judged drowsy by analysts watching videos of them, slept significantly less prior to driving than drivers who did not appear drowsy; however, the mean difference was small (285 minutes vs. 298 minutes, or 14 minutes mean difference). The authors did not find a relationship between time in bed and drowsiness, or the duration of sleep two or three days prior and drowsiness.

Key Question 3: How do motorcoach drivers differ from truck drivers in terms of the following attributes:

A. Demographics (gender, age, race/ethnicity, and other demographic characteristics)?

In this section, we assessed the prevalence of gender, race/ethnicity, age, education level, income, marital status, and job tenure among truck drivers and motormotorcoach/bus drivers. Our examination of data from the Bureau of Labor Statistics (BLS) and 23 studies – two focusing on bus and one on coach drivers – revealed several likely differences. They are:

- **Gender**. The majority of truck and motorcoach/bus drivers are male. Additionally, the percentage of women who drive motorcoach/bus (22.2 percent, data based on only three studies) appears to be higher than women who drive trucks (4.5 percent). Although more females appear to drive motorcoach/bus, the estimated range is broad (12 to 24.5 percent), according to data obtained from only three motorcoach/bus studies. A more precise estimate is not possible with the available data. *(Strength of Evidence: Moderate)*
- **Age**. Based on data from 17 studies, the weighted mean age of truck drivers is 43.7 years. Data from three motorcoach/bus driver studies suggest the average age of this driver group is 48 years. This is consistent with estimates from the BLS for the more broadly defined groups of bus and truck drivers with median ages of 44.3 and 49.46 years, respectively. *(Strength of Evidence: Moderate)*
- **Income**. Motor coach drivers tend to have lower incomes than commercial truck drivers, but this disparity in income is reducing. *(Strength of Evidence: Moderate)*
- **Job tenure**: Motorcoach/bus drivers tend to have more years on the job than commercial truck drivers. *(Strength of Evidence: Minimally Acceptable)*

Limited data precluded us from drawing a conclusion on the following attributes. However, BLS data – containing more broadly defined groups of bus and truck drivers – showed the following:

- **Race/Ethnicity.** More white and Hispanic drivers drive truck (82.8 and 16.6 percent, respectively) than motorcoach/bus (69.5 and 12 percent, respectively). More black drivers drive motorcoach/bus (26.6 percent) than truck (13.7 percent). Based on data from eight studies, the mean percent of white truck drivers (82 percent) is similar to the BLS data. However, data was retrieved from only one study (Escoto and French, 2012) of transit bus drivers in a Midwestern U.S. city, with limited generalizability across different geographical locations. The study showed 59 percent of its participants were white and 41 percent non-white.
- **Education level.** A slightly larger proportion of truck drivers (17.6 percent) than motorcoach/bus drivers (10.6 percent), on average, do not have a high school diploma. The percentage of truck drivers (53 percent) and motorcoach/bus drivers (50.7 percent) who finished high school but did not attend college was statistically close. Data from three truck driver studies showed 20 percent did not finish high school and 40.8 percent had a high school diploma. One bus driver study (Escoto and French, 2012) found that 45.8 percent of its participants had a high school diploma and 39.8 percent had some college.

A paucity of literature for truck and motorcoach/bus drivers regarding marital status precludes conclusions about difference between the two driver groups.

B. Job Function (Loading requirements, light work duties, driving time, etc.)?

In this section, we assessed roads travelled, distance travelled, driving time, total time worked, loading requirements, light work duties, pre-trip operations, and opportunities for rest among truck and motorcoach/bus drivers. Our examination of 16 studies, four of which focus on motorcoach/bus drivers, offers three differences in job function characteristics. They are:

- **Roads travelled**: Based on available data from two studies, long-haul truck drivers spend most of their driving time on the interstate and transit bus drivers spend most of their driving time in the city; however, one in three bus drivers spends half his/her time equally in the city and suburbs. Few spend most of their time in the suburbs. No data was available for coach drivers. *(Strength of Evidence: Minimally Acceptable)*
- **Distance travelled**: Based on data from seven studies, truck drivers drive more miles per trip and per week. The average length per trip for truck drivers (557.8 miles) is longer than the average travelled by coach drivers (250 to 300 miles), with a mean difference of at least 257.8 miles. On average, coach drivers drive nearly half as many miles per week than truck drivers: 1,200 miles vs. 2,449 miles. *(Strength of Evidence: Minimally acceptable)*
- **Driving time:** Based on data from six studies, bus drivers drive slightly fewer hours than truck drivers, on average. About 60 percent of long-haul truck drivers drive 10 hours or less per day compared to bus drivers, who average between 8 and 9 hours of driving per day. One study reported a mean driving time of 9.4 hours for truck drivers, and another reported 8.58 for bus drivers. Data was not available for coach drivers. *(Strength of Evidence: Insufficient)*

A paucity of literature for truck and motorcoach/bus drivers regarding the following topics precludes conclusions about difference between these two driver groups:

- Loading requirements
- Light work duties
- Pre-trip operations
- Opportunities for rest

C. Work Environment (Interaction with passengers, access to health care, scheduling/shift cycles, etc.)?

In this section, we assessed control over trips, interactions with passengers, cabin ergonomics, scheduling/shift cycles, access to health care, employment/industry culture, potential exposure to harmful substances, quality of rest/sleep, and opportunity for exercise among truck drivers and motorcoach/bus drivers. Our examination of 20 studies, four of which are motorcoach/bus driver studies, provided two differences in work environment characteristics. They are:

- **Employment/industry culture:** Based on data from one study, both truck and coach drivers feel pressure to bend driving rules because of dispatchers. On a scale of 1 to 7 (7 meaning a lot of pressure), both driver groups scored in the 3 range, with truck drivers reporting a mean number of 3.98 and coach drivers a 3.13. A significant difference was found between truck and coach drivers on personal motivations to continue driving when tired. Truck drivers reported a mean score of 6.59 on the 1 to 7 scale, meaning to a very large extent, whereas coach drivers reported a mean score of 2.63, meaning to a lesser extent. *(Strength of Evidence: Minimally acceptable)*

- **Scheduling/shift cycles:** Based on data from five studies, bus drivers have a more consistent schedule than truck drivers. *(Strength of Evidence: Insufficient)*

A paucity of literature for truck and motorcoach/bus drivers regarding the following topics precludes conclusions about difference between these two driver groups:

- Control over trips
- Interactions with passengers
- Cabin ergonomics
- Access to health care
- Potential exposure to harmful substances
- Quality of rest/sleep
- Opportunity for exercise

D. Health-Related Behaviors/Disease Characteristics (Smoking Status, BMI, etc.)?

In this section, we assessed smoking status, BMI, physical activity, stimulant use, alcohol use, general health, HIV/AIDS, cancer, cardiovascular disease, cerebrovascular disease, respiratory conditions, renal/CKD, endocrine disease, neurological disease, musculoskeletal disorders, mental health/suicide, and vision and hearing disorders among truck drivers and motorcoach/bus drivers. Our examination of 28 studies offers only one similarity in health characteristics of the two driver groups.

Based on data from nine truck driver studies and one bus driver study, the majority of truck and bus drivers are overweight or obese. The mean BMI for bus drivers is 32.7 kg/m^2 and 32.30 kg/m^2 for truck drivers. *(Strength of Evidence: Minimally Acceptable)*

A paucity of literature for truck and motorcoach/bus drivers regarding the following topics precludes conclusions about difference between these two driver groups:

- Smoking status
- Physical activity
- Stimulant use
- Alcohol use
- General health
- HIV/AIDS
- Cancer
- Cardiovascular disease
- Cerebrovascular disease
- Respiratory conditions.

- Renal/CKD
- Endocrine disease
- Neurological disease
- Musculoskeletal disorders
- Mental health/suicide
- Vision and hearing disorders

Key Question 4: Do identified differences between motorcoach and truck drivers increase (or decrease) the risks for acute non-pathologic fatigue?

Demographics

Based on comparisons between coach/coach and truck drivers in Key Question 3A, our review found that motorcoach/bus drivers are more likely to be older, female, comprising more nonwhite drivers, earning less money, and having more experience.

The literature suggests that two key variables are likely to increase the risk for acute fatigue, placing motorcoach/bus drivers more at an increased risk:

- **Older age:** (Di Milia et al., 2011[35]; Muecke, 2004[36]; and Nicholson, 1999[37])
- **Female gender:** (Tiesinga et al., 1999[38]; and Di Milia et al., 2011[35])

No other demographic variables were identified that would either increase or decrease the risk for acute fatigue for motorcoach/bus drivers when compared with truck drivers.

Job Function

Based on comparisons between motorcoach/bus and truck drivers in Key Question 3B, our review found that motorcoach/bus drivers are more likely to drive on city roads, fewer miles, and for slightly fewer hours. Despite these results, only one attribute (miles per day) represents coach drivers.

The literature suggests that exposure to three key variables is likely to increase the risk for acute fatigue, placing motorcoach/bus drivers at a decreased risk for acute fatigue when compared to truck drivers:

- **Monotonous driving conditions** (Eskandarian et al., 2007[39]; Lal and Craig, 2001[40]; and Williamson et al., 2011[41])
- **Long driving hours** (Caruso et al., 2004[42]; Duke et al., 2010[43]; Horne and Reyner, 1999[44]; and Lal and Craig, 2001[40])
- **Long work hours** (Eskandarian et al., 2007[39]; Lal and Craig, 2001[40]; Morrow and Crum, 2004[45]; Nicholson, 1999[37]; and Van der Hulst, 2003[46])

Work Environment

Based on comparisons between motorcoach/bus and truck drivers in Key Question 3C, our review found that motorcoach/bus drivers are more likely to have more consistent scheduling and feel slightly less pressure from dispatchers to bend driving rules. Despite these results, only one attribute (dispatcher pressure) represents coach drivers.

Our literature review of fatigue risk factors in this section suggests that exposure to three key variables is likely to place motorcoach/bus drivers at a decreased risk for acute fatigue:

- **The pressure of making deliveries on time** (Morrow and Crum, 2004[45]).

Other work environment characteristics that are consistently associated with increased risk for acute fatigue include:

- **Shift work** (night work/irregular work hours, both of which interfere with the circadian rhythm) (Akerstedt et al., 2003[47]; Apostolopoulos et al., 2010[48]; Lal and Craig, 2001[40]; Leibowitz et al., 2006[49]; Morrow and Crum, 2004[45]; Muecke, 2004[36]; and Nicholson, 1999[37])
- **Sleep debt** (Akerstedt et al., 2003[47]; Apostolopoulos et al., 2010[48]; Duke et al., 2010[43]; Eskandarian et al., 2007[39]; Leibowitz et al., 2006[49]; Muecke, 2004[36]; Nicholson, 1999[37]; Niu et al., 2011[50]; Smolensky et al., 2011[51]; and Williamson et al., 2011[41])

Health-Related Behaviors and Disease Characteristics

Based on comparisons between motorcoach/bus and truck drivers in Key Question 3D, our review found that motorcoach/bus drivers are as likely to be overweight or obese as truck drivers.

The literature suggests that obesity is a key variable to increase the risk for acute fatigue:

- **Obesity** (Duke et al., 2010[43]; Smolensky et al., 2011[51]; and Vgontzas et al., 2006[52])

The only health-related data available for both motorcoach/bus and truck drivers pertain to obesity. On average, both motorcoach/bus and truck drivers are overweight and/or obese, with an average BMI of 32.7 kg/m^2 (based on a single study) and 32.3 in kg/m^2 (based on eight studies), respectively, placing both groups at an increased risk for acute fatigue based on their BMI.

Other health-related characteristics that are consistently associated with increased risk for acute fatigue include:

- **Sleep apnea/Sleep-disordered breathing (**Duke et al., 2010[43]; Eskandarian et al., 2007[39]; Leibowitz et al., 2006[49]; Smolensky et al., 2011[51]; and Vgontzas et al., 2006[52])
- **Restless legs syndrome** (Leibowitz et al., 2006[49]; and Smolensky et al., 2011[51])
- **Diabetes** (Smolensky et al., 2011[51]; and Vgontzas et al., 2006[52])
- **Depression and/or anxiety** (Leibowitz et al., 2006[49]; Smolensky et al., 2011[51]; Tiesinga et al., 1999[38]; and Vgontzas et al., 2006[52])

A paucity of data for motorcoach/bus drivers, however, makes it difficult to examine whether they are at an increased (or decreased) risk for acute fatigue based on differences between these health-related variables.

Preface

Organization of Report

This evidence report contains four sections: 1) *Background* 2) *Methods*, 3) *Evidence Synthesis,* and 4) *Appendices*.

The *Background* section provides an overview of non-pathologic fatigue and sleepiness pertinent to the operation of commercial motor vehicles of any type, presents the Federal Motor Carrier Safety Administration's (FMCSA's) definitions of CMVs and motorcoaches and the most current number of vehicles in operation, and summarizes U.S. and selected international hours-of-service (HOS) regulations.

Methods provides an overview of how information was identified and analyzed, including:

- Key questions
- Literature searches
- Retrieval and inclusion criteria
- Evaluation of study risk of bias
- Rating overall evidence

Evidence Synthesis is organized by key question. For each question, we report on the quality and quantity of the studies that provided relevant evidence. We then narratively synthesize findings across studies into conclusions, and provide an overall summary.

Scope

This purpose of this report is to assess and characterize the relationship between crash and fatigue in generally healthy motorcoach drivers. As definitions of "fatigue" and "healthy" vary, the evidence in this assessment includes whatever study authors define as fatigue, and comprises studies on drivers with non-pathologic fatigue (ie, fatigue not caused by a sleep, medical, or health issue). In the context of the operation of CMV of any type, non-pathologic fatigue is caused by factors such as insufficient sleep, disrupted circadian cycles, and driving-related stress or monotony.

Assessment of drivers with obstructive sleep apnea and other sleep disorders or medical conditions known to be associated with fatigue or sleepiness is outside the scope of this report. These topics have been examined by the FMCSA in previously published reports. These reports can be downloaded from the FMCSA Website (http://www.fmcsa.dot.gov/rules-regulations/topics/mep/mep-reports.htm).

This evidence report addresses key questions posed by the FMCSA, which carefully formulated them for the use of examining current medical examination guidelines.

Key Question 1: What impact does non-pathologic fatigue have on crash incidence and driving ability?

Key Question 2: How much rest does a fatigued professional driver need to resume driving unimpaired?

Key Question 3: How do coach drivers differ from truck drivers in terms of the following attributes:

a. Demographics (gender, age, smoking status, etc.)?
b. Job function (pre-trip preparations, roads and distances travelled, opportunities for rest, etc.)?
c. Work environment (interactions with passengers, cabin ergonomics, schedules, shift cycles etc.)?
d. Health-related behaviors and disease characteristics (body mass index, caffeine and alcohol use, depression, cancer, etc.)?)

Key Question 4: Do identified differences between coach and truck drivers increase (or decrease) the risks for non-pathologic fatigue?

Background

Fatigue and Driving

An estimated 2.46 million CMV drivers carried goods or passengers on America's roadways in 2011, of which[53]:

- 1,508,620 million were heavy and tractor-trailer drivers
- 771,210 were light truck or special delivery services workers
- 176,190 were motormotorcoach/bus drivers

Of these, 3,511 large trucks and buses were involved in fatal crashes the year before, with trucks accounting for 94 percent of them and motorcoaches/buses for 6 percent.[1][54]

Motor vehicle crash is a major cause of morbidity and mortality in the United States. According to the National Highway Traffic Safety Administration (NHTSA), it was the 11th most common cause of death in 2009, accounting for more than 32,500 deaths in people younger than 65 years.[55] Although the proportion that involved motorcoaches is not reported, nearly 7,000 buses and 43,000 large trucks were involved in injury crashes in 2009. Buses and trucks were respectively associated with 15,327 and 59,703 injuries and 254 and 3,380 deaths.[54] More than three-quarters of these fatalities were occupants of other types of vehicles.

The driving task is complex and requires that an individual simultaneously receive several sensory inputs, process this information, and then act in a coordinated manner (Figure 1). Visual, auditory and vestibular function, proprioception, arousal, perception, learning, memory, attention, concentration, emotion, reflex speed, time estimation, and decision making are among the factors that interact to produce coordinated responses. Anything that interferes with these factors, to a significant degree, may impair driving ability.

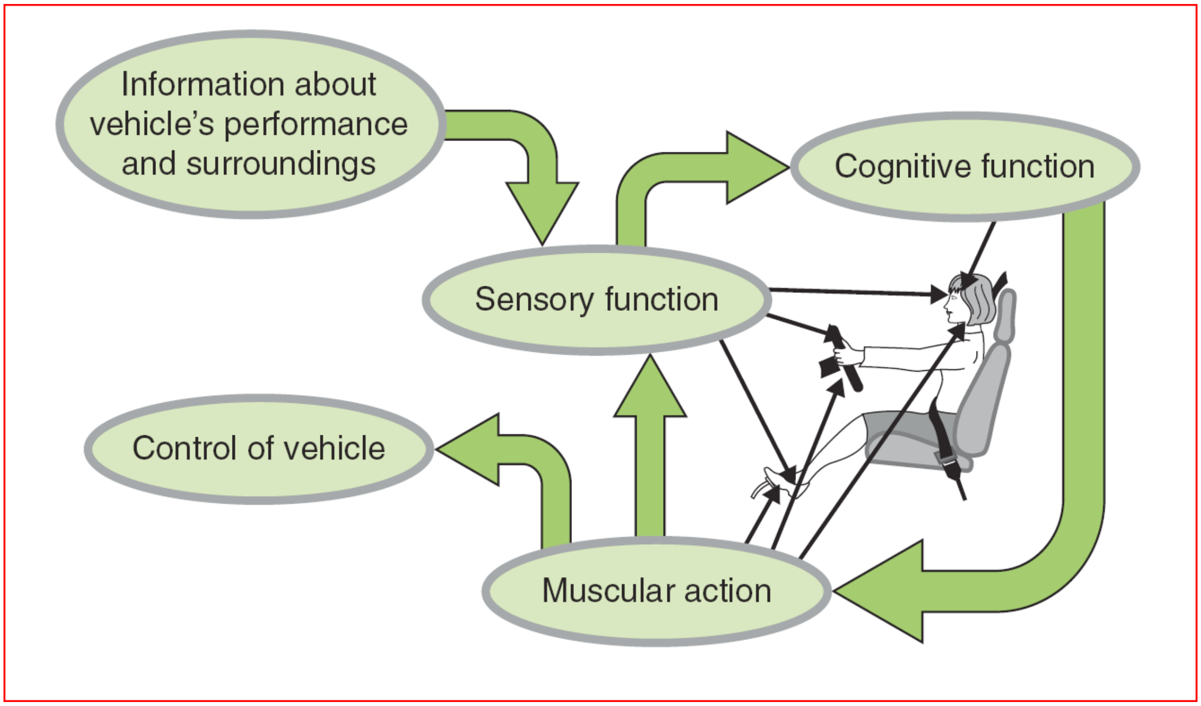
Fatigue (tiredness or weariness) and sleepiness (drowsiness, or difficulty staying awake) are known to impair functions required for safe driving, including reaction time, maintaining attention, and processing and integrating information.[56-58] As stated in the *Scope*, the purpose of this evidence report is to assess the relationship between crash and fatigue or sleepiness in generally healthy drivers, individuals who do not have an underlying medical condition known to cause fatigue or excessive daytime sleepiness.

Horne and colleagues reviewed sleep-related vehicle accidents and found driver sleepiness is due to insufficient sleep or going to bed too early in generally healthy people; not caused by sleep-related disorders or other pathology.[59] Drowsy driving might also be more likely to occur on the roadways used for long-distance drives, such as monotonous interstates. Eighty-one percent

[1] Crash data comes from two sources: the Fatality Analysis Reporting System (FARS) and the Motor Carrier Management Information System (MCMIS). Although MCMIS data is provided for 2010, the latest year for combined FARS and MCMIS data is 2009.

of drivers in a survey by Royal et al., 2003[60] reported their drowsy driving event occurred on a multi-lane interstate or two-lane road with a speed limit of at least 45 miles per hour.

Figure 1. The Driving Task



Carter 2006[61]

Causes and treatment of sleep-related fatigue (eg, insufficient sleep, circadian disruption) and task-related fatigue differ.[62] The National Center on Sleep Disorders Research (NCSDR) and the NHTSA identified the following as characteristic of sleepiness-related crash:[63]

- Late night/midafternoon time of day
- Serious crash
- Single vehicle
- Driver alone in vehicle
- High-speed roadway
- Vehicle ran off road

The NCDSR and NHTSA reported commercial driving may predispose drivers to drowsiness, particularly if drivers engage in the following:[63]

- Driving long hours per day
- Driving between midnight and 6 a.m.
- Driving midafternoon
- Driving long durations without break
- Driving many miles annually

Fatigue and sleepiness, as addressed in this report, can be categorized in non-exclusive categories that encompass these causative factors:

- Insufficient sleep
- Circadian disruption
- Task fatigue

The following sections present more information on fatigue risk factors as they relate to driving.

Insufficient Sleep

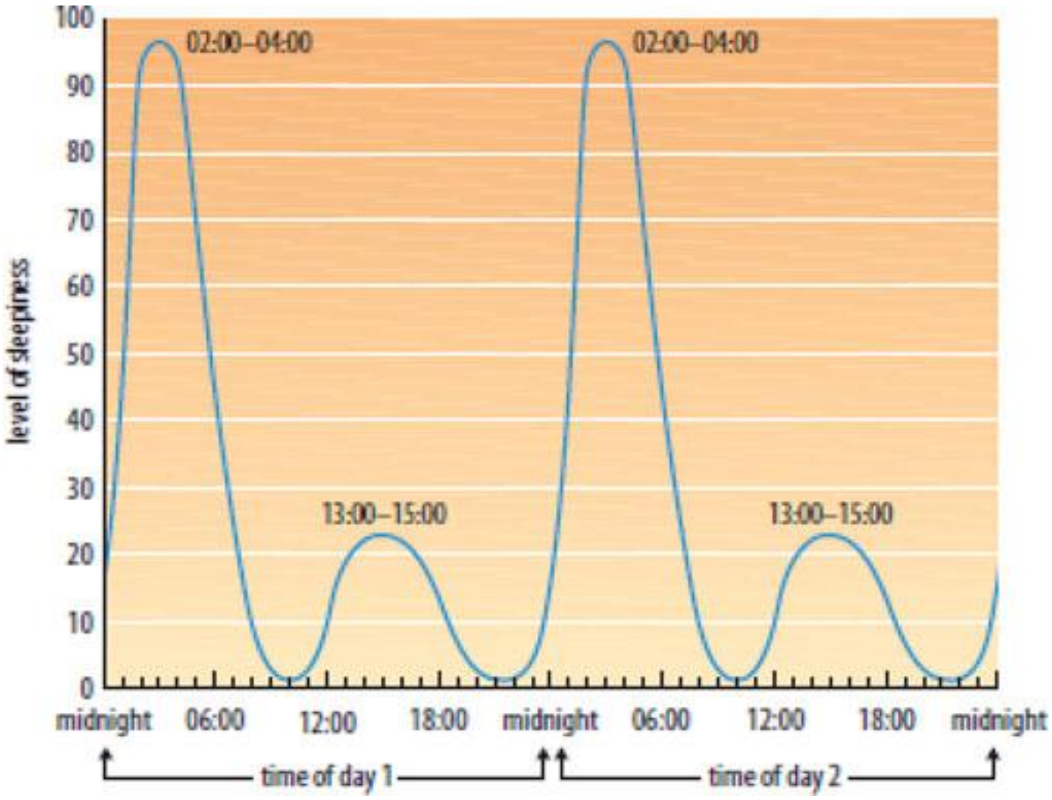
The average adult needs about seven to eight hours of sleep nightly to maintain adequate general function. Typically, adults are awake for 16 to 17 hours at a time. Studies suggest professional drivers sleep less on average,[64] and, consequently, they are awake longer. A 2007 study conducted after the 2003 HOS regulation changes reported that a sample of U.S. truck drivers, under real-world conditions, slept an average of 6.28 hours (standard deviation 1.42 hours) a day.[31] Even a small deficit of overnight sleep can, over time, cause driving-related impairment, and the impact of the sleep debt is cumulative and can be expected to worsen over time.[59, 65, 66] The Commercial Transportation Operator Fatigue Management Reference states insufficient sleep can be caused by extended work and/or commuting periods; lack of rest during work; and sleep disruption due to environmental factors such as noise. [67] Staying on schedule, sleeping away from home, and lack of opportunity for rest during drives are all common aspects of professional driving that can contribute to insufficient sleep. A tight delivery schedule has been associated with drowsy driving, presumably because drivers do not have enough time to rest.[68]

Although most people know that rest or sleep has the potential to alleviate drowsiness, many studies report rest is a much less frequently chosen response to drowsy driving than other tactics, such as opening windows, having a coffee, talking, or playing the radio.[25, 60, 69, 70] A 2003 survey performed for the National Highway Traffic Safety Administration found taking a nap was the No. 1 action by truck drivers (43 percent).[60]

Circadian Factors or Disruption

Research has shown that individuals are most prone to fatigue between the hours of midnight and 6 a.m. and between 2 p.m. and 4 p.m., as shown in Figure 2.

Figure 2. Circadian Rhythm in Sleepiness



Source: International Petroleum Industry Environmental Conservation Association/ International Association of Oil and Gas Producers[71]

In addition to working during these times, changing and rotating work schedules and unpredictable work schedules can create or exacerbate fatigue. The Commercial Transportation Operator Fatigue Management Reference reported these as typical issues in operating commercial vehicles.[67] Some researchers have concluded the time of day is a more important factor in crash than drive duration.[59]

Task-related Fatigue

Driving demands constant vigilance, and the constant stimulation yet monotony of it can contribute to boredom and impair stimulus response. May and Baldwin, 2009[62], differentiate two types of driving fatigue: active and passive. Active driving fatigue is due to demanding mental conditions, such as traffic, poor visibility, or bad weather. Passive driving fatigue is due to non-stimulating and, generally, predictable driving conditions, such as monotonous highway driving. Driving long hours and taking insufficient breaks may contribute to these fatiguing effects.[67]

Commercial Motor Vehicles and Motorcoaches

According to the FMCSA, a CMV is a vehicle that is used as part of a business and is involved in interstate commerce and fits *any* of these descriptions:[72]

- Weighs 10,001 pounds or more
- Has a gross vehicle weight or gross combination weight rating of 10,001 pounds or more
- Is designed or used to transport 16 or more passengers (including the driver) not for compensation
- Is designed or used to transport 9 or more passengers (including the driver) for compensation
- A vehicle that is involved in interstate or intrastate commerce and transporting hazardous materials in a quantity requiring placards is also considered a CMV."

Motorcoaches are a type of CMV defined by FMCSA as "a bus designed for long-distance transportation of passengers and characterized by an elevated passenger deck over a baggage compartment."[73] The FMCSA further describes motorcoaches by the following characteristics:[74]

- Seats approximately 40 to 60 passengers
- Subject to driving time limitations
- Restroom facilities onboard
- Ideal for long trips
- Available storage areas for luggage and equipment.

Hours of Service Regulations

HOS regulations administered by the FMCSA[72] differ for property-carrying CMVs (eg, tractor-trailers) and passenger-carrying CMVs (eg, motorcoaches), as summarized in Table 2.

Table 2. FMCSA Hours of Service Regulations: Property vs. Passenger-Carrying[72]

Factor	Property-Carrying CMV Drivers (Valid through July 1, 2013)	Passenger-Carrying CMV Drivers
Driving Limit	May drive a maximum of 11 hours after 10 consecutive hours off duty	May drive a maximum of 10 hours after 8 consecutive hours off duty.
Hour On-Duty Limit	May not drive beyond the 14th consecutive hour after coming off duty, following 10 consecutive hours off duty. Off-duty time does not extend the 14-hour period.	May not drive after having been on duty for 15 hours, following 8 consecutive hours off duty. Off-duty time is not included in the 15-hour period.
60/70 On-Duty Limit	May not drive after 60/70 hours on duty in 7/8 consecutive days. A driver may restart a 7/8 consecutive day period after taking 34 or more consecutive hours off duty.	May not drive after 60/70 hours on duty in 7/8 consecutive days.
Sleeper Berth Provision	Drivers using the sleeper berth provision must take at least 8 consecutive hours in the sleeper berth, plus a separate 2 consecutive hours either in the sleeper berth, off duty, or any combination of the two.	Drivers using a sleeper berth must take at least 8 hours in the sleeper berth, and may split the sleeper-berth time into two periods provided neither is less than 2 hours.

Table 3 shows key points of HOS regulations for the United States, Australia, Canada, and the European Union. This table presents the most current information and follows the format used by Blanco et al. (2011)[26]. More detailed regulations are provided in Appendix G, including source document information.

Table 3. Comparative Summary of International Hours of Service Regulations

Regulation	Australia[a]	Canada[b]	European Union[c]	NAFTA/ Mexico-domiciled	United States/ FMCSA[c¤]
Maximum On-Duty Time	17 Hours	14 hours per day	Not Specified	15 hours following 8 consecutive hours off duty	15 hours following 8 consecutive hours off duty
Maximum Daily Driving Time	Not Specified	13 hours per day	9 hours per day	10 hours following 8 consecutive hours off duty	10 hours following 8 consecutive hours off duty
Maximum Continuous Driving Time	5 hours	Not Specified	4.5 hours	Not Specified	Not Specified
Minimum Mandatory Break Time	20 minutes after 5 hours of working	Not Specified	45 minutes after 4.5 hours of driving	Not specified	Not specified
Time Off After Days of Driving	27 hours in 72 hours working	36/72 hours in 70/120 hours working	45 hours after 6 days of driving	8 consecutive hours off after 10 hours of driving	8 consecutive hours off after 10 hours of driving
Total Driving Time per Period	168 hours in 14 days	70/120 hours in 7/12 days	56 hours per week (7 days)	60/70 hours in 7/8 consecutive days respectively	60/70 hours in 7/8 consecutive days respectively

[a]Western Australia
[b]South of Latitude 60˚ N
[c]Passenger carrying

Methods

The section summarizes how we identified and analyzed information, including: key questions addressed; literature searches; retrieval and inclusion criteria; evaluation of study risk of bias; synthesis methods; and rating overall evidence supporting conclusions. Details are documented in appendices.

Key Questions

This evidence report addresses four key questions developed by FMCSA to inform evaluation of current medical examination guidelines.

Key Question 1: What impact does non-pathologic fatigue have on crash incidence and driving ability?

Key Question 2: How much rest does a fatigued professional driver need to resume driving unimpaired?

Key Question 3: How do coach drivers differ from truck drivers in terms of the following attributes:

a. Demographics (gender, age, smoking status, etc.)?
b. Job function (pre-trip preparations, roads and distances travelled, opportunities for rest, etc.)?
c. Work environment (interactions with passengers, cabin ergonomics, schedules, shift cycles etc.)?

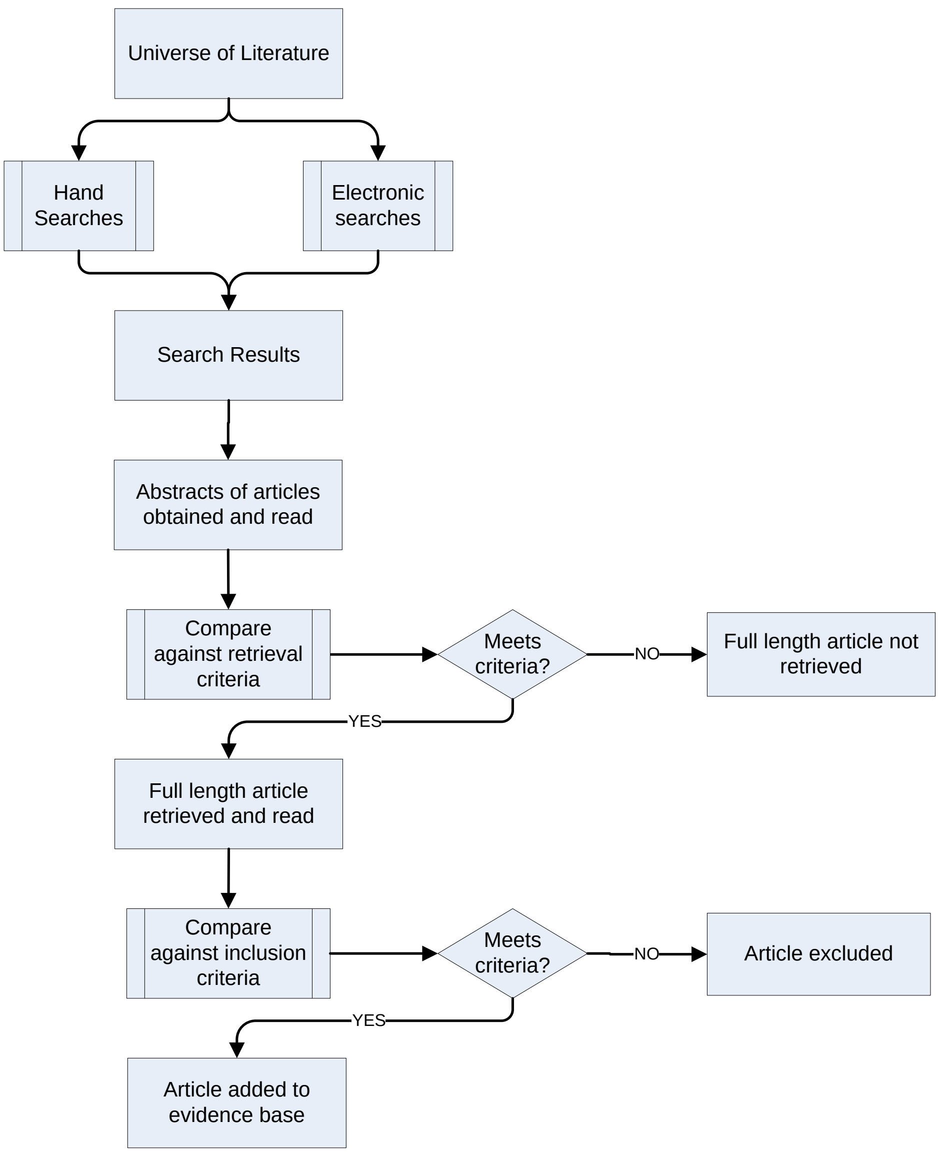
d. Health-related behaviors and disease characteristics (body mass index, caffeine and alcohol use, depression, cancer, etc.)?)

Key Question 4: Do identified differences between coach and truck drivers increase (or decrease) the risks for non-pathologic fatigue?

Identification of Evidence Base

We identified articles using the multistage process presented in Figure 3. As described in the subsections that follow, we (1) searched the literature; (2) applied retrieval criteria to titles and abstracts to select articles for full review; and (3) applied full inclusion criteria to full-length articles to determine which to include.

Figure 3. Evidence Base Identification



Literature Searches

Systematic literature searches are rigorous, transparent, and reproducible. MANILA staff developed search strategies using a combination of free-text terms and controlled vocabulary concepts derived from the National Library of Medicine's (NLM's) Medical Subject Headings (MeSH) in multiple electronic databases. Full details of the search strategies are presented in Appendix A.

Electronic Searches

We searched the databases listed in Table 4, using strategies shown in Appendix A.

Table 4. Electronic Databases Searched

Name	Platform/Provider
Cumulative Index to Nursing and Allied Health Literature (CINAHL)	http://ebscohost.com/
EMBASE	http://ebscohost.com/
PsychInfo	www.apa.org/psychinfo
PubMed (pre MEDLINE)	http://ebscohost.com/
The Cochrane Library	www.thecochranelibrary.com
Transportation Research Information Database (TRID)	http://trid.trb.org/

Manual Searches

We reviewed journals, non-journal publications, and conference proceedings from professional organizations, private agencies, and government agencies. We reviewed approximately 700 relevant documents provided by the FMCSA. We also examined the reference lists of all obtained articles to ensure all relevant literature was identified. Hand searches were also performed for "gray literature," which is not indexed in peer-reviewed literature. Gray literature consists of reports, studies, articles, and monographs produced by federal and local government agencies, private organizations, educational facilities, consulting firms, and corporations.

Application of Retrieval Criteria

We applied retrieval criteria, which were determined *a priori* in conjunction with the FMCSA during title and abstract review of identified citations, to determine which publications meet inclusion criteria and should be retrieved for full evaluation. All retrieval criteria are listed in Appendix B. Many of these criteria are question-specific to ensure relevance. The following applied to all key questions:

- Article must be published in the English language.
- Article must assess adults aged at least 18 years.
- Study participants must be generally healthy; studied fatigue or sleepiness must be non-pathological.
- Article must appear to be a full-length publication.

Application of Inclusion Criteria

A researcher read each retrieved article in full and applied inclusion criteria to determine whether the publication should be included. These criteria were determined *a priori* in conjunction with the FMCSA. These criteria ensure that general criteria (listed above under Application of Retrieval Criteria) were satisfied, that no included data were redundant or counted the same individual more than once for the same outcome, and were relevant to the key question. These criteria are presented in Appendix C. Articles not meeting inclusion criteria were excluded and listed in the table of excluded studies in Appendix D.

Methods of Evidence Synthesis

For each key question, a researcher designed data table shells and extracted relevant data, and a senior researcher assessed completeness and accuracy of data abstraction. Extracted data included study design characteristics, driver characteristics, and outcomes data. These data tables appear throughout the report.

Although the purpose of this report is to address motorcoach driver safety, due to an insufficient amount of evidence specific to motorcoach drivers, each key question included other types of drivers. Key Question 1 and Key Question 2 included other professional drivers and nonprofessional drivers. Key Question 3 included studies with local transit bus drivers. The key questions were divided by types of driver population.

To address the potential relationship between crash and driving patterns among professional drivers in Key Question 1, the evidence was organized by factors such as daily or weekly driving time, time off, and time of day. To address driving ability in Key Question 1, the evidence was divided by cause of non-pathologic fatigue (ie, circadian effects, insufficient sleep, task-related fatigue, or none specified) and then organized by driving ability outcomes.

To address duration of rest needed for recovery in Key Question 2, the evidence was divided by break type (ie, during shift, overnight, reset or weekend) and then organized by function, fatigue, and sleepiness outcomes. Once the studies and outcomes were organized into compatible data sets, their findings are described, compared, and contrasted and considered as a whole to narratively synthesize the information into conclusions.

Data for Key Question 3, which assesses the difference between motorcoach/bus drivers and truck drivers, are divided into four sections: demographics, job function, work environment, and health-related behaviors and disease characteristics. Each section is further broken down into subsections (ie, gender, race, age, marital status for demographics).

Key Question 4 highlights the differences found among the driver groups in Key Question 3, discussing identified differences that might make motorcoach/bus drivers more or less prone to fatigue than truck drivers.

Rating Strength of Evidence

We rated the strength of evidence in two steps. First, we critically appraised the risk of bias of individual studies to inform the quality of the overall evidence base (body of studies addressing a key question and specific outcome). Second, we considered these ratings along with consistency, robustness, and amount of evidence, and where relevant, magnitude of effect, to rate the strength of evidence supporting conclusions.

Assessment of risk of bias of individual studies using instruments selected *a priori* provides an objective and transparent method for identifying potential threats to the credibility of evidence. Risk of bias assessment guides interpretation of findings from studies considered individually, and when combined with additional studies to address a key question, it provides insight into the potential risk of bias that might have influenced the studies' findings. To assess individual studies' risk of bias, we used instruments from the Joanna Briggs Institute for non-comparative and controlled experimental studies, and the Newcastle Ottawa assessment instruments for cohort and case-controlled studies. These instruments and links to the original versions with instructions are provided in Appendix E.

We used the risk of bias ratings of individual studies and the following additional factors of the total evidence base for each outcome to determine the strength of evidence supporting our conclusions: overall quality, quantity, consistency, robustness, and, where relevant, magnitude of effect. Definitions of these factors and additional details are provided in Appendix F.

Table 5 defines the strength of evidence ratings applied in this report. These definitions are intuitive: Conclusions supported by strong evidence are less likely to be overturned by the publication of new data than conclusions supported by minimally acceptable evidence. At times, no conclusion is possible because factors, such as insufficient amount of evidence or excessive risk of bias, strongly compromise the credibility of a finding. In these instances, we describe the studies and their findings but stipulate that the evidence is 'insufficient' to warrant an evidence-based conclusion.

Table 5. Strength of Evidence Ratings

Strength of Evidence	Interpretation
Strong	Evidence supporting the conclusion is convincing. It is highly unlikely that new evidence will lead to a change in this conclusion.
Moderate	Evidence supporting the conclusion is somewhat convincing. There is a small chance that new evidence will overturn or strengthen our conclusion. Regular monitoring of the relevant literature for moderate-strength conclusions is recommended.
Minimally acceptable	Although some evidence exists to support the conclusion, this evidence is tentative and perishable. There is a reasonable chance that new evidence will either overturn or strengthen our conclusions. Frequent monitoring of the relevant literature is recommended.
Insufficient	Although some evidence exists, the evidence is insufficient to warrant drawing an evidence-based conclusion. Frequent monitoring of the relevant literature is recommended.

Evidence Synthesis

This section summarizes the findings of our systematic review of the evidence pertaining to each of the key questions asked by FMCSA.

Key Question 1A: What impact does non-pathologic fatigue have on crash incidence?

In this section, we examined the impact of non-pathologic fatigue on crash by 1) summarizing important previous work, and 2) providing assessments of the literature and highlighting gaps in the information. Specifically, we present statistics associating crash with fatigue or sleepiness; summarize findings from a 2009 FMCSA-commissioned report; and conduct two *de novo* analyses on questions not addressed by the aforementioned work.

In the first new analysis, we searched for relevant literature on fatigue or sleepiness and crash in healthy individuals only. This analysis was intended to provide information on the impact of non-pathologic fatigue on crash, and be free from the potentially confounding influence of sleepiness or fatigue consequent to a health or medical issue. Second, we assessed the influence of driving patterns and fatigue. Driving patterns include anything related to driving schedule, such as time-of-day driving, hours driven per day and week, and duration of breaks and rest.

Fatigue, Sleepiness, and Crash Statistics

Data on motorcoach crash is limited compared to truck crash or personal vehicle crash data. NHTSA data show cross-country and intercity bus crashes account for about 50 fatalities and 1,000 injuries of bus occupants annually in the United States, as reported in 2010 by the FMCSA.[75] In addition, bus crashes caused about 225 fatalities among occupants of other vehicles and 100 fatalities among pedestrians and bicyclists.[76] In FMCSA's Large Truck and Bus Crash Facts Report, driving while drowsy, asleep, or fatigued contributed to 33 (5.5%) single-vehicle crashes and 13 (0.5%) multiple vehicle crashes among drivers of large trucks in fatal crashes in 2009.[77] Among passenger vehicle drivers, the numbers and percentages were 486 (2.8%) for single-vehicle crashes and 0.8% (190) for multiple vehicle crashes. NHTSA data show that drowsy driving, which includes driving while sleepy, fatigued, or asleep, accounted for 832 deaths in 739 crashes or about 2.5 percent of all U.S. crash fatalities in 2009. In addition, reports of injury (from 30,000 crashes) and property damage without injury or death (from 41,000 crashes) were attributed to drowsy driving.[60] In a 2002 nationwide survey performed for the NHTSA, 37 percent of drivers reported having nodded off at least once while driving (11 percent in the year before), although only 0.7 percent of drivers who had a collision in the previous five years attributed their crash to drowsiness.[60]

International assessments report the proportion of crashes that are fatigue or sleepiness-related is higher. An analysis by the Australian Transport Safety Bureau estimated fatigue played a role in 16.6 percent of all Australia's fatal crashes in 1998, with 30 percent involving an articulated truck.[65] A 1995 study conducted in the southwest England concluded that sleep was an issue in

16 percent of all crashes, and 20 percent of those on Midlands motorways.[78] In 2004, the Swedish National Road Administration estimated that fatigue or sleepiness was a factor in 15 to 20 percent of truck crashes, noting that in official records the estimates are lower due to underreporting.[79]

Surveys have independently found that large proportions of professional and private drivers admit to driving while drowsy or even nodding off while driving.[60, 69, 79] Despite this, evidence suggests that people who are asleep for only a short period of time (but long enough to cause a crash) have no memory of falling asleep.[59] As drivers may be reluctant to report falling asleep at the wheel, or may not recall having nodded off, most investigators use objective criteria to estimate frequency of fatigue-related crash.[59]

Summary of Findings from 2009 FMCSA-commissioned Report: Daytime Sleepiness and Commercial Motor Vehicle Safety

All studies assessed in the 2009 FMCSA-commissioned report, *Daytime Sleepiness and Commercial Motor Vehicle Safety*, reported a statistically significant association between subjective measures of excessive daytime sleepiness (most often measured using the Epworth Sleepiness Scale [ESS]) with the risk of crash in both commercial and personal vehicle drivers. These drivers were not selected for healthfulness. Acute measures of sleepiness, most often determined by the quantity of sleep prior to a crash or near miss, were also found to significantly increase risk for sleep-related crash.

Table 6 provides a summary of the individual study findings. In each study, chronic sleepiness and/or acute sleepiness measures are significantly associated with increased crash or near-miss risk.

Table 6: Quick-view Summary of the Results of Studies on Sleep-related Crash Risk

Study	Determination of Chronic Sleepiness	Chronic Sleepiness Increased Risk?	Determination of Acute Sleepiness	Acute Sleepiness Increased Risk?	Measure of Sleepiness Relative to Incident
Hanowski et al. (2007)[31] Prospective cohort study	--	--	Objective measure of sleep quantity using actigraphy; Video monitoring of sleepiness	▲	Simultaneous
Dingus et al. (2006)[80] Prospective cohort study	--	--	Karolinska Sleepiness Scale; Video monitoring of sleepiness	▲	Simultaneous
Gander et al. (2006)[81] Retrospective cohort study	ESS	--	General Questionnaire about immediate prior sleep	▲	Close in time following crash
Perez-Chada et al. (2005)[25] Retrospective cohort study	ESS	▲	--	--	Variable (data report on crash at any time in past)
Sabbagh-Ehrlich et al. (2005)[82] Retrospective cohort study	General questionnaire	▲	--	--	Variable (data report on crash at any time in past)
Souza et al. (2005)[83] Retrospective cohort study	ESS PSQI	▲	--	--	Variable (data report on crash within past 5 yrs)

Study	Determination of Chronic Sleepiness	Chronic Sleepiness Increased Risk?	Determination of Acute Sleepiness	Acute Sleepiness Increased Risk?	Measure of Sleepiness Relative to Incident
Howard et al. (2004)[84] Retrospective cohort study	ESS FOSQ	▲	--	--	Variable (data report on crash within past 3 yrs)
Carter et al. (2003)[61] Retrospective cohort study	ESS Self-assessed sleep debt	▲	--	--	Variable (data report on crash within past 10 yrs)
Mitler et al. (1997)[85] Prospective cohort study	--	--	Objective measure of sleep quantity using polysomnography; Electroencephalography; Video monitoring of sleepiness	▲	Simultaneous
Maycock et al. (1997)[86] Prospective cohort study	ESS	▲	--	--	Variable (data report on crash within past 3 yrs)

ESS – Epworth Sleepiness Scale; FOSQ – Functional Outcomes of Sleep Questionnaire; PSQI – Pittsburg Sleep Quality Index

A potential issue with these findings is that drivers included in these studies were often assessed for sleep-related factors at some variable time following the crash or near miss. The use of "current" daytime sleepiness measures (ie, measured at the time of the study) as a proxy measure for past sleepiness is likely a source of bias. This is a problem for studies that measured current sleepiness relative to recalled crashes and/or near misses from some time in the distant past. Studies that attempted to link assessments of sleepiness closer in time to the prior crash are likely to be better assessments of sleep-related crash risk (Hanowski et al., 2007[31]; Dingus et al., 2006[80]; Gander et al., 2006[81]).

Perhaps the best measures come from naturalistic data collection systems, such as those used in Dingus et al. and Hanowski et al., which assessed fatigue and critical incidents during real-life driving scenarios. These types of studies increase the external validity of the results obtained, because drivers are evaluated as the events happen. Moreover, these studies are less likely to be impacted by recall bias as described above, because assessments of sleepiness were simultaneously obtained during the period during which the crash and/or near miss data were collected.

One of the primary findings of Dingus et al. was that the frequency of critical incidents (near misses) and fatigue-related critical incidents varied significantly by the hour of the day. The largest number of incidents (corrected for exposure), as well as the largest number of cases of "very drowsy" single drivers, occurred in the late afternoon and early evening hours; thus, fatigued driving at periods of high traffic periods appeared to be a significant risk factor in the occurrence of critical incidents. Furthermore, the authors found that approximately 20 percent of severe critical incidents were caused by extreme (ie, head-bobbing) fatigue. Dingus et al. also assessed the occurrence of fatigue and sleepiness in single and team drivers, finding that single drivers had higher levels of self-reported daytime sleepiness and were more likely to have critical and severe critical incidents than team drivers.

In Hanowski et al., fatigue and/or sleep-related critical incidents were significantly related to the amount of sleep a driver received on the day prior to driving and self-reported drowsiness prior to the critical incident. Drivers slept less before the critical incident compared to the overall mean sleep quantity during the study. Collectively, the findings of both studies, along with those obtained from epidemiological studies, suggest that crash risk is significantly related to fatigue and/or sleepiness at the wheel that arises from either chronic sleep problems and/or acute sleep restriction.

New Analyses

- ***Crash, and Fatigue or Sleepiness in Healthy Drivers***
- ***Crash and Driving Patterns in Professional Drivers***

Identification of Evidence Base

We conducted one literature search comprising strategies to address both questions about fatigue and crash. Strategies are shown in Appendix A. Our searches identified 1,268 potentially relevant articles. We reviewed the titles and abstracts of these articles and applied criteria to determine which to retrieve for full review. The article must have been an English-language, full-length publication that enrolled at least 10 drivers and assessed the relationship of crash with fatigue. Following application of the retrieval criteria, shown in Appendix B, 169 articles were retrieved and read in full.

After the review, we applied inclusion criteria to ensure the retrieval criteria were satisfied and that the articles were original and controlled or comparative studies that addressed crash incidence and fatigue. These criteria are shown in Appendix C. To address fatigue or sleepiness and crash in healthy drivers, the study must have assessed the relationship of non-pathologic fatigue and crash in drivers who are free from any potentially confounding medical, sleep, or other health issue. To address crash and driving patterns in professional drivers, the study must have assessed the potential relationship between driving patterns and crash in professional drivers. After review, 158 were excluded for the following reasons: does not address the key question (k= 50) or no crash data reported (k= 31); did not address either crash in healthy drivers or driving patterns in professional drivers (k=38); not a study with original data (k=31); estimated outcomes data (k=7); not English-language (k=1).

No studies were identified that addressed fatigue, sleepiness, and crash in drivers selected for health. Therefore, no analysis on this question was possible. Eleven articles describing 10 studies met inclusion criteria for professional driving patterns and crash. The study selection process is illustrated in Figure 5. See Table 13 for the included studies. Appendix D lists the articles that were retrieved, reviewed, and excluded, with reason for exclusion.

Figure 4. Development of Evidence Base for Key Question 1A, Crash

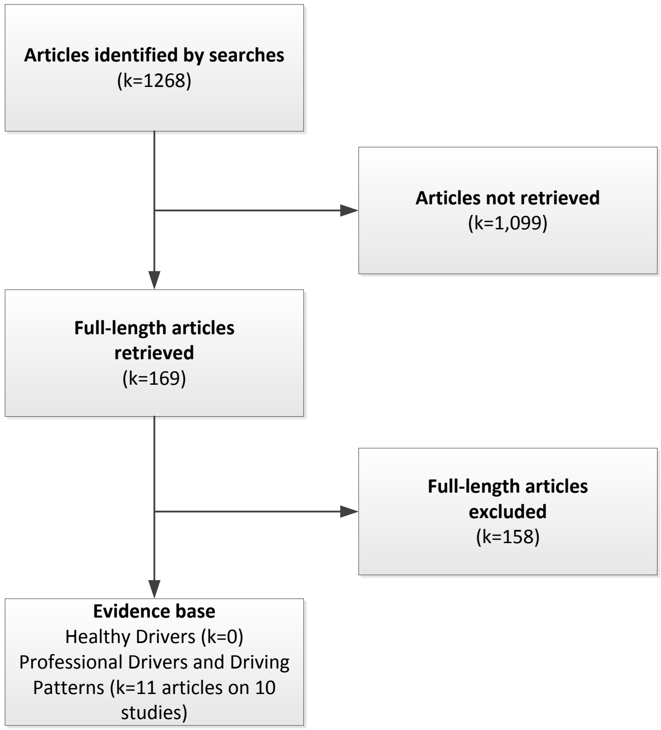


Table 7. Evidence Base for Key Question 1A: Driving Patterns and Crash in Professional Drivers

Reference	Year	Study Location
Jovanis et al.[3]; Wu and Jovanis[3]	2011	United States
Sando et al.[11]	2010	United States, Florida
Hickman et al.[7]	2005	United States
Park et al.[2]	1987	United States, Washington State
McCartt et al.[6]	1997	United States, Nationwide
Massie et al.[9]	1997	United States, New York State
National Transportation Safety Board[10]	1996	United States, Alabama, California, Georgia, New Jersey, North Carolina, and Texas
Jovanis et al.[8]	1991	United States, Nationwide
Kaneko and Jovanis [1]	1991	United States, Nationwide
Jones and Stein [5]	NR	United States, Nationwide

Evidence Base Description

Key design characteristics of studies addressing driving patterns and crash in professional drivers are summarized in Table 19. All studies assessed real-world crash in professional drivers. Most studies collected data on these crashes using record review or assessment, such as company logs or national database information. One study conducted a survey that required recall of crash and driving patterns,[6] and one observed drivers with special recording equipment during normal vehicle operation.[7] These studies used various methods to analyze their data, including cluster cohort analyses (in which drivers with similar driving patterns were grouped into clusters, and the crash incidence of the clusters were compared), case-control comparisons, and simple tabulations (eg, relative frequency of time of day crash occurred). Reported driving patterns assessed for association with crash in the included studies were time of day, daily and weekly driving time, split driving day, and time off.

Key driver characteristics are summarized in Table 15. None of the studies assessed outcomes of motorcoach drivers. One assessed city bus transit drivers.[11] The remaining assessed long- or short-haul truck drivers. In all studies, drivers were medically fit for commercial driving, but none were selected for health. As most studies used records to collect data, inclusion criteria typically described how the records were obtained (eg, obtained from a particular company during a particular year), but they did not specify driver characteristics, such as health. Descriptions of drivers were, in general, poor, so characterizing the drivers in the overall evidence base was therefore not possible.

Table 8. Key Study Design Characteristics for Key Question 1A: Driving Patterns and Crash in Professional Drivers

Reference	Year	Study Design	Risk of Bias	Study N Analyzed	Data Collection Method	Sample Type	Outcome Addressed				
							Time of Day	Driving Time, Daily	Driving Time, Weekly	Split Duty	Time Off
Jovanis et al[3].; Wu and Jovanis[3]	2011	Cohort cluster analysis	Moderate	1,564 drivers and same number crashes; 878 (318 case, 560 control) truckload, 686 (224 case, 462 control) less than truckload	Driver logs (paper or electronic) and crash information requested form carriers	Records, all (crash), random (control)					✓
Sando et al.[11]	2010	Case-control	Moderate	899 crashes: 222 preventable collisions, 677 non-crash controls	Record review	Completed time cards, all during randomly selected weeks	✓		✓		
Hickman et al.[83]	2005	Randomized controlled trial (RCT), assessed as single-arm time series	High	95 drivers	Observation, naturalistic driving	Volunteer	✓				
Park et al.[2]	2005	Cohort cluster analysis	Moderate	5050 drivers (1,841 crash, 3,110 not in crash)	Record review	NR	✓	✓			✓
Massie et al.[9]	1997	Assessed as single-arm time series	High	Not reported, thousands	Record review	Records, random	✓				
McCartt et al.[6]	1997	Cross-sectional with 5-year crash recall	High	593 drivers	Survey (recall of driving patterns and crash required)	Random selection of drivers at survey sites	✓		✓	✓	
National Transportation Safety Board[10]	1996	Cross-sectional with recall	High	107 drivers	Record identification of crash, survey collection of rest of data (recall of service hours required)	All pertinent records	✓				
Jovanis et al.[8]	1991	Cohort cluster analysis	Moderate	"Nearly" 1,600 total (crash and no crash)	Record review	NR	✓	✓	✓*		
Kaneko and Jovanis [1]	1991	Cohort cluster analysis	Moderate	"Over" 1,000 drivers	Record review, driver logs	NR	✓	✓			
Jones and Stein[5]	1987	Case-control	Moderate	676 crashes with 734 trucks, plus 2,022 controls	Record review	All crashes meeting criteria, controls random	✓	✓			

NR – Not reported

* Days per week

Table 9. Key Driver Characteristics for Key Question 1A: Driving Patterns and Crash in Professional Drivers

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
Jovanis et al.[3]; Wu and Jovanis[3]	2011	Truck drivers, truckload and less-than-truckload	Driver working for company participating in the study Crash involved fatality, injury requiring medical treatment not at crash scene, or tow-away	NR	NR	NR	NR	NR
Sando et al. [11]	2010	Bus drivers from transit agencies; appear to be mostly city drivers	Records from one of four agencies	NR	NR	NR	NR	NR
Hickman et al. [7]	2005	Truck drivers with class A commercial driver's license	"Significant proportion" of driving at night Do not wear glasses to drive (interferes with data collection) Not expected to drop out Passed vision and hearing tests	NR	99%	Caucasian 65% African-American 32% Asian-American 1% Native American 1% Hispanic American 1%	39.5 (24-60)	Mean 10 years (Range 15 months to 42 years)
Park et al.[2]	2005	Less than truckload drivers	Working for participating company None additional reported	NR	NR	NR	NR	NR
McCartt et al. [6]	1998	Truck drivers, long-distance	Truck drivers at private rest areas, public rest areas, and inspection sites At least 6 months experience driving tractor trailer At least occasional trips of >2 days Drove >50,000 miles/year for work	NR	99%	NR	35% were 35-54 years	78% had >5 years' experience 88% drove >85,000 miles annually for work 61% drove >100,000 miles annually for work
Massie et al. [9]	1997	Truck drivers, short-haul	Record in national survey database	NR	NR	NR	NR	NR
National Transportation Safety Board[10]	1996	Truck drivers, heavy trucks 50 on long-haul and 57 on short-haul trip when crash occurred	Single-vehicle crash that occurred between 9/1992 and 6/1993 Driver survived crash Truck >26,000 pounds gross weight	NR	NR	NR	38 (range 20-67)	13 (range 1-37)
Jovanis et al.[8]	1991	Truck drivers	NR	NR	NR	NR	NR	NR
Kaneko et al.[1]	1991	Less than truckload drivers, primarily	NR	NR	NR	NR	NR	NR

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
Jones and Stein[5]	1987	Truck drivers, tractor-trailers	Trucks that crashed in Washington state and controls driving in crash local at same day of week and time of day one week later Trucks >10,000 pounds Crash >$1,500 property damage, or personal injury	NR	NR	NR	NR	NR

NR – Not reported

Risk of Bias Assessment

An overview of the bias risk assessment is shown in Table 16. An itemized assessment of each study is shown in Appendix E. Overall, the evidence received a moderate to high rating for the risk of bias. Because assessing crash in typical controlled experimental study designs is logistically prohibitive, these data are derived from real-world natural sources, such as record assessments, survey, and observation. These types of study designs are conducted in the context of the complex real world and are always susceptible to confounding influences that could affect study results. However, they are of value because the realism of such studies increases the generalizability of the data to actual professional driving patterns.

The greatest potential source of bias for this evidence base is information bias – the risk that the data analyzed were incorrect. This is of particular concern for the studies that relied upon driver recall to determine crash incidence, driving patterns, or both. Fortunately, most studies relied on objective records. However, even objective records may be unreliable if they are inaccurate, which may be a concern for driver logs or recorded hours of service. Most of the driver logs in this evidence base were not electronically recorded.

Another potential source of bias relevant to this evaluation in light of the focus on non-pathologic fatigue is driver medical and sleep health status. None of the included studies evaluated drivers for health or adjusted analyses accordingly.

The summary of findings and instrument used are shown in Table 10. An itemized assessment for every study is provided in Appendix E.

Table 10. Bias Risk Assessment for Key Question 1A: Driving Patterns and Crash in Professional Drivers

Reference	Year	Scale Used	Risk of Bias
Jovanis et al.[3]; Wu and Jovanis[3]	2011	Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)	Moderate
Sando et al.[11]	2010	Newcastle Ottawa Assessment Scale for Case Control Studies (Revised)	Moderate
Hickman et al. [7]	2005	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Jones and Stein [5]	1987	Newcastle Ottawa Assessment Scale for Case Control Studies (Revised)	Moderate
Massie et al. [9]	1997	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
McCartt et al.[6]	1998	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
National Transportation Safety Board[10]	1996	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Kaneko and Jovanis et al.[1]	1991	Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)	Moderate
Jovanis et al.[8]	1991	Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)	Moderate
Park et al.[2]	NR	Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)	Moderate

NR – Not reported

Generalizability of Evidence Base to Motorcoach Drivers

The generalizability of this evidence on driving ability to real-world motorcoach drivers is poor. No studies presented data on motorcoach drivers. One study assessed transit bus drivers, but the driving tasks and patterns of city drivers are different from motorcoach drivers. The rest of the studies addressed truck drivers. While this evidence is indirect, the tasks and responsibilities of motorcoach and truck drivers should be sufficiently similar that the data are still useful. Furthermore, the types of outcomes measured, such as time of day for greatest crash incidence or risk associated with a particular drive time, should be relevant.

As noted in the previous section, *Risk of Bias Assessment*, there is a tradeoff between risk of bias and generalizability. Health was not considered as a potentially confounding variable in any of the included analyses, and while that may pose a potential risk of bias, it also means the studies' samples are more representative of real-world professional drivers.

Findings

The following text describes key findings followed by a description of the evidence supporting those findings. Results from included studies are also presented in Table 11.

Motorcoach Drivers

No studies specific to motorcoach drivers were identified.

Professional Drivers

Evidence suggests that the incidence of crash increases after 5 or 6 hours of driving and continues to increase through the end of driving time at 8 to 11 hours. *(Strength of Evidence: Moderate)*

Crash incidence is generally highest during overnight and early morning hours, and increased in the afternoon. *(Strength of Evidence: Minimally Acceptable)*

No other conclusions were possible because only one study or two conflicting studies addressed other driving patterns.

Driving Time, Daily

Time driven during the day was reported by five studies, described in the following text. Each assessed daily driving time in a slightly different way, but results consistently suggested that longer driving time is associated with increased risk of crash. However, perhaps due to the differences in methods, these studies do not uniformly point to a clear cut-off time after which crash increases. Notably, the longest duration of driving assessed varied from 8 to 11 hours.

Studies found crash incidence started to increase after 5 or 6 hours of driving. Kaneko et al., 1991[1], found crash risk was highest during the first hour of driving, which was not replicated in other studies. After this initial elevated risk, the crash risk was at the lowest level between hours 1 and 5 before it began to increase. Park et al., 2005[2], similarly found crash risk increased after the first 5 hours of continuous driving, and Jovanis et al., 2011[3, 4], found it increased after the first 6 hours of driving.

After the first 5 to 7 hours of driving, studies generally found the crash incidence continued to rise. Park et al. found crash incidence rose significantly after 5 hours of continuous driving, as did Kaneko et al. Jovanis et al., 2011[3], found that in less-than-truckload trucks, crash incidence increased after the 6th hour of driving, and in truckload loads it increased after the 7th.

With one exception, the rest of the studies found greater crash incidence with even longer driving duration. Park et al. reported that crash incidence did not continue to significantly increase during continuous driving hours 5 through 10. Jones and Stein, 1987[5], found drivers who drove more than 8 hours were more likely to be in a multiple-car crash and had a higher crash incidence than drivers driving only 2 hours. Kaneko et al. noted, though, that it found crash risk continued to increase up to the 9th hour of continuous driving. McCartt et al., 1998[6], found that drivers who drove more than 10 consecutive hours were more likely to have been in a crash in the preceding 5 years. Jovanis et al. found that crash increased up to the 11th hour of driving, with the highest odds of crash at the 11th hour.

This evidence suggests that the incidence of crash increases after 5 or 6 hours of driving and continues to increase through the end of driving time at 8 to 11 hours. We rate the evidence supporting this conclusion as moderate despite the moderate to high risk of bias rating, because studies consistently identified this trend despite differences in study design.

Time of Day

Nine studies assessed the relative frequency of crash by time of day, as described in the following text. Six studies (Hickman et al., 2005[7]; Park et al. 2005[2]; Jones and Stein, 1987[5]; Jovanis et al., 2011[8]; Massie et al., 1997[9]; and NTSB, 1996[10]) observed greater crash incidence in overnight to early morning hours, generally between midnight and 8 a.m. (with some variation in time frame assessed among studies). Massie et al. also observed another peak in crash between 3 p.m. and 5 p.m. Two studies had contrary findings. Kaneko at al. observed higher crash incidence among drivers who operated their vehicles in the afternoon and evening, and suggested this could be due to greater traffic congestion during those time. Sando et al.[11] found transit bus crash incidence was lowest between midnight and 4 a.m. and highest between 1 p.m. and 7 p.m. It attributed this to greater routes and risk exposure in the afternoon and evening.

This evidence suggests crash incidence is generally highest during overnight and early morning hours, and increased in the afternoon. We rate the strength of evidence supporting this conclusion as minimally acceptable due to the moderate to high risk of bias rating and some variability in findings.

Time Off

Two studies assessed the impact of time off on crash incidence upon return to work. Park et al., 2005[2], performed a cluster analysis based on variant work schedules and found the effect of extended time-off duty was unclear. Jovanis et al., 2011[3, 4], found that the odds of crash after a 34-hour restart period increased, and suggested this may because the cumulative effects of driving do not reset to zero after such a break. Two studies with inconsistent findings did not provide sufficient evidence to support an evidence-based conclusion.

Split Off-Duty Rest

One study, McCartt et al., 1998[6], found that 29 percent of drivers who split or varied their longest sleep period had a crash during the 5 years prior to the survey, compared to 20 percent of drivers who did not. A single study provides an insufficient amount of evidence to support an evidence-based conclusion.

Driving Time, Weekly

One study, Sando et al., 2010[11], reported on the association between weekly driving time and crash among transit bus drivers. For both comparisons, drivers who crashed worked significantly more hours. They reported that, among drivers who did not work a split shift, those who crashed worked a mean of 49.8 hours and those who did not worked a mean of 43.5 hours. Among those with split shift, those who crashed worked a mean of 54.4 hours and those who did not worked a mean of 47.7 hours. Sando et al. further noted that crash increased steadily with weekly driving time more than 40 hours per week measured in 5-hour increments, especially after 55 hours per week. A single study provides an insufficient amount of evidence to support an evidence-based conclusion.

Days Driven per Week

One study, Jovanis et al., 1991[3, 4], assessed number of days driven per work week and found that drivers who drove 8 days in a row had a higher crash incidence than those who today days 6 and 7 off. A single study provides an insufficient amount of evidence to support an evidence-based conclusion.

Working Time, Weekly

McCartt et al., 1998[6], found that the crash incidence during the previous 5 years steadily increased with hours driven per week up to 80 hours per week. The average hours worked and proportion who crashed were: Fewer than 50, 15%; 51-60, 20%; 61-70, 21%; 71-80, 30%; at least 81, 17%. The authors noted that the lower crash risk among drivers working at least 80 hours per week was correct, but did not propose an explanation. A single study provides an insufficient amount of evidence to support an evidence-based conclusion.

Table 11. Key Question 1a. Driving Patterns and Crash in Professional Drivers

Pattern Addressed	Findings	Reference	Year
Days driven per week	Drivers who drove during the sixth or seventh day in a work week instead of taking those days off had a higher crash incidence on the eighth day. The authors suggest this may be due to cumulative effects of driving.	Jovanis et al.[8]	1991
Driving time, continuous	Crash risk was highest in the first hour of driving, lowest between 1 through 5, and then increased until 9th hour, after which it was as high as the first hour again. The authors suggest this could be because local roads to access the interstates are higher risk, or because drivers acclimate during the first hour. The note that the increased risk after the 9th could be due to cumulative driving effects and return to local access roads.	Kaneko et al.[1]	1991
	During 10 hours of drive time, the incidence of crash increased compared to the first driving hour. Crash was significantly higher at hours 5 through 10 than baseline and hours 2 through 4. Crash incidence did not significantly differ among hours 5 through 10. The authors note the data suggest that crash incidence increases slightly through the first 4 hours of driving and then significantly at and after 5.	Park et al. [2]	2005
	Drivers who drove more than 10 consecutive hours were more likely to crash in the previous 5 years than drivers who did not. 26% of drivers who always or often drove at least 10 consecutive hours crashed in the previous 5 years, compared to 28% who sometimes did, 20% who rarely did, and 16% who never did.	McCartt et al.[6]	1997
Driving time, daily (Unclear whether continuous)	Crash olds was associated with duration of drive time. In less than truckload trucks, crash odds increased statistically significantly with driving time after the 6th hour, and highest odds in the 11th hour, with a p value of less than 0.20 (determined as significant by study authors in the interest of public safety). In truckload trucks, the crash increased between 7 and 11 hours driving.	Jovanis et al.[3]; Wu and Jovanis[3]	2011
	10% of crash had driven more than 8 hours since last 8 hour rest period, vs. 6% who did not crash. Drivers driving more than 8 hours had higher crash incidence than those driving 2 hours; they were 1.8 times more likely to have crashed (relative risk). Drivers driving more than 8 hours were 2.6 times more likely to be in a multiple-car crash, but the difference was not significant for single-car crash (relative risk).	Jones and Stein [5]	1987
Split off-duty rest	Drivers who split or varied their longest sleep period between day and night were more likely than drivers who did not to crash in the previous 5 years (28.8% vs. 20%).	McCartt et al.[6]	1997
Split shift and weekly driving time	Without shift splits: drivers who crashed worked an average of 49.81 hours in the week before the crash, and those who did not worked an average of 43.52 hours before the crash. This difference was statistically significant and represents a mean difference of 6.29 hours. The relative proportion of crash for drivers steadily increased in 5-hour intervals past 40 hours per week, from about 0.25 for the first 40 hours to about 1.5 for 55-60 or >60 hours. With shift split: drivers who crashed worked an average of 53.67 hours, and those who did not worked an average of 47.70 hours, also statistically significant. The mean difference is 5.97 hours. The relative proportion of crash for drivers steadily increased in 5-hour intervals past 40 hours per week, from about 0.25 for the first 40 hours to about 1.25 at 50-55 hours, but the escalated more sharply to 2 at 55-60 hours and 4 at >60 hours. Note this population is transit bus drivers.	Sando et al.[11]	2010
Time of day	Crash risk is elevated between midnight and 8 am. Incidence is highest between 4 and 6 am.	Jovanis et al.[8]	1991
	70/107 crashes occurred between 10 p.m. and 8 am, of which 52/70 (74%) were fatigue related. 37/107 crashes occurred between 8 a.m. and 10 pm, and 10/37 (27%) were fatigue related.	NTSB[10]	1996

Pattern Addressed	Findings	Reference	Year
	The greatest number of crashes occurred at 5 a.m. (n=19), followed by 7 a.m. (n=13) and 3 a.m. (n=11)		
	Two databases assessed with similar findings, as follow. In Trucks Involved in Fatal Accidents (TIFA) data, The percent of fatal crashes attributed to fatigue in records was highest between 2 a.m. (8%) and 7 a.m. (10%), and peaked at 5 a.m. (14%). A second peak occurred between 3 and 5 pm, when around 8.7% of fatal crashes occurred. Data estimated from figure. Distributions were similar in SafetyNet data.	Massie et al.[9]	1997
	The highest incidence of crashes was 2 crashes per hour measured. This occurred 3 times: between 1 and 2 am; 3 and 4 pm; and 5 and 6 pm. The first two are consistent with circadian nadirs, and the second may be affected by rush hour congestion. However, there were only 14 crashes total in this study; the study is underpowered to determine whether time of day is significantly associated with crash.	Hickman et al.[7]	2005
	Based upon cluster analyses of variant work schedules, the authors concluded that night and early morning “rather conclusively” increases crash risk compared to daytime driving.	Park et al. [2]	2005
	The fewest bus crashes occurred between midnight and 4 am. The authors note this reflects the reduced number of routes and reduced exposure. Preventable collisions were most frequent between 1 p.m. and 7 p.m. (56%), and highest between 1 p.m. and 3 p.m. (26%). (Assessed here as single-arm time series – frequentist univariable assessment.)	Sando et al.[11]	2010
Time of day and daily driving time	The relative risk was higher between 12 a.m. and 6 a.m. and between 6 a.m. and noon than it was between noon and 6 p.m. or 6 p.m. to midnight.	Jones and Stein [5]	1987
Time of day, pattern	Over the course of weekly driving, night and early morning driving patterns had the lowest crash incidence, and daytime and early evening driving had the highest.	Jovanis et al.[8]	1991
	Over the course of weekly driving, afternoon and evening drivers had higher crash incidence than night and early morning drivers. The authors note this may be due to decreased congestion during night and early morning.	Kaneko et al.[1]	1991
Time off	Based upon cluster analyses of variant work schedules, the authors concluded that the effect of extended off-time duty on crash incidence was unclear.	Park et al.[2]	2005
	Crash odds increased after a recovery period of at least 34 hours. The authors infer this may mean that cumulative driving hours may not restart to zero after a restart break. The lowest odds of crash were for starting the drip during the day without a recovery break.	Jovanis et al.[3]; Wu and Jovanis[3]	2011
Working time, weekly	Drivers who drove 71-80 hours per 7 days had the highest crash incidence in the previous 5 years. Their rate was higher than among drivers working at least 81 hours per week. ≤50: 14.6%; 51-60: 20%; 61-70: 21%; 71-80: 30%; ≥81: 17.3%.	McCartt et al.[6]	1997

Section Summary

Statistics show a clear connection between driving while fatigued or sleepy and crash in professional drivers. Data specific to motorcoach drivers are relatively limited, due perhaps to the relative infrequency of motorcoach crashes. Previous FMCSA-sponsored evidence review of peer-reviewed published literature corroborated the clear association between sleepiness or fatigue and crash. However, an unknown proportion of drivers assessed in these previous analyses had health or sleep issues that may have confounded the relationship between fatigue and crash incidence. New literature searches performed for this report did not identify any studies that assessed fatigue and real-world crash in healthy drivers only.

Table 12 summarizes the key findings of our assessment on driving patterns and crash in professional drivers. Moderate-strength evidence suggests that the incidence of crash increases after 5 or 6 hours of driving and continues to increase through the end of driving time at 8 to 11 hours. Minimally acceptable evidence suggests crash incidence is generally highest during overnight and early morning hours, and increased in the afternoon. For other outcomes, lack of replication or inconsistent findings rendered the data insufficient to support evidence-based conclusions.

This scope of this assessment was strictly limited to real-world crash. For data on critical incidents and near misses and crash in simulators, please read the next section, *Driving Ability*.

Table 12. Summary Findings on Driving Patterns and Crash in Professional Drivers

Reference	Year	Outcome Addressed				
		Time of Day	Driving Time, Daily	Hours or Days Worked, Weekly	Split Duty	Time Off
Jovanis et al.; Wu and Jovanis[3]	2011		↑ After 6 hours ↑↑ To 11 hours			↑ After 34 hours
Sando et al.[11]	2010	↑ Afternoon / Evening		↑ More hours, especially >55 hours		
Hickman et al.[83]	2005	↑ Overnight /Early morning				
Park et al.[2]	2005	↑ Overnight /Early morning	↑ After 5 hours			Unclear
Massie et al.[9]	1997	↑ Overnight /Early morning				
McCartt et al.[6]	1997		↑ After 10 hours	↑ >50 hours total working time	↑ For split or varied sleep	
National Transportation Safety Board[10]	1996	↑ Overnight /Early morning				
Jovanis et al.[8]	1991	↑ Overnight /Early morning		↑ 8th day if worked 6th and 7th		

Kaneko and Jovanis [1]	1991	↑ Overnight /Early morning, and Afternoon	↑ After 5 hours ↑↑ To 9 hours			
Jones and Stein[5]	1987	↑ Overnight /Early morning	↑ After 8 hours			

↑ indicates increase in crash incidence. ↑↑ indicates continued increase in crash incidence.

Key Question 1B: What impact does non-pathologic fatigue have on driving ability?

In this section, we examine the impact of non-pathologic fatigue or sleepiness on driving performance, measured by real-world driving and driving simulator studies. Real-word driving studies measure driving ability using special vehicles with instruments that measure driving performance and/or an expert passenger who assesses driving performance, or video monitoring or driver and vehicle. Driving simulator studies collect driving ability measures in a computer-generated driving environment.

Although this question is intended to assess driving ability in healthy drivers, we did not exclude drivers for whom health status was not reported, because previous FMCSA-supported systematic review work does not address the impact of fatigue or sleepiness on driving ability (as was the case for crash). However, we did exclude drivers who clearly had a health or sleep issue that could impact driving, such as obstructive sleep apnea.

Identification of Evidence Base

Database search strategies for Key Question 1B are provided in Appendix A. We applied retrieval criteria to determine which of these studies should be evaluated in full. Full retrieval criteria are listed in Appendix B, and focused on identifying the effect of non-pathological fatigue or sleepiness on driving ability in adults in original full-length English-language studies. Following application of the retrieval criteria, 98 articles were retrieved and read in full.

During full review, inclusion criteria, listed in Appendix C, were used to ensure that appropriate studies were systematically and objectively selected for inclusion. These inclusion criteria verified that criteria set forth as retrieval criteria were satisfied, that no redundant data or duplicate studies were included, and that driving ability outcomes were compared between rested and fatigued or sleepy conditions.

After review, 70 were articles excluded for the following reasons: does not address the key question (k=48), not a study with original data or analysis (k=11); not a comparative study (k=4); insufficient information to determine whether the study meets inclusion criteria (k=4); drivers had sleep disorder (k=2); fewer than 10 participants enrolled (k=1). See Table 13 lists the 28 included articles describing 26 studies, and which are divided by the types of drivers they enrolled. The study selection process for Key Question 1B is illustrated in Figure 4.

Figure 5. Development of Evidence Base for Key Question 1B: Driving Ability

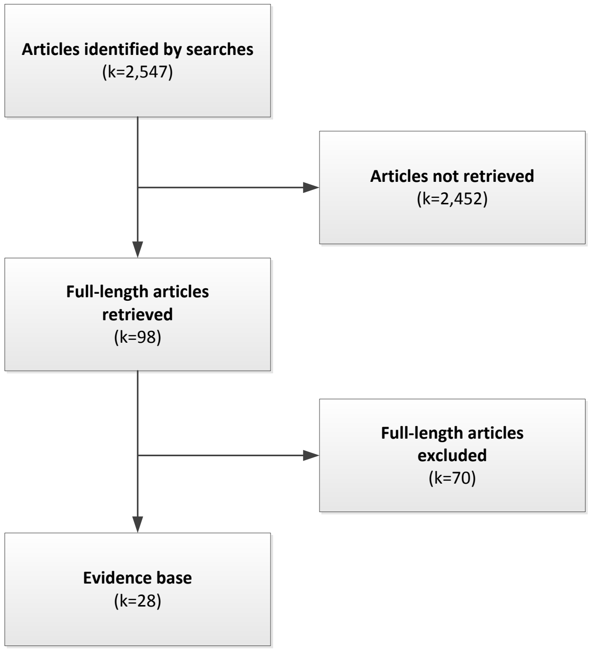


Table 13. Evidence Base for Key Question 1B: Driving Ability

Reference	Year	Study Location	Setting
Professional Drivers			
NTRCI / Fine et al.[87]	2012	USA	Driving simulator
Barr et al.[34]	2011	USA	Real-world driving
Naturalistic Truck Driving Study (Blanco et al. 2011; Soccolich et al. 2012)[14, 15]	2011	USA	Real-world driving
Kee et al.[88]	2010	Malaysia	Driving simulator
Mortazavi et al.[89]	2009	Unclear	Driving simulator
Drowsy Driver Warning System Study (Hanowski et al. 2007; Hanowski et al. 2009) [12, 13]	2007 2009	USA	Real-world driving
Howard et al.[90]	2007	Australia	Laboratory (sleep center) with driving simulator
Hanowski et al.[91]	2003	USA	Real-world driving
Commercial Motor Vehicle Driver Fatigue and Alertness Study (Wylie et al. 1996)[64]	1997	USA	Real-world driving
Fuller[92]	1983	Ireland	Real-world driving
Non-Professional Drivers			
Matthews et al. [19]	2012	Australia	Driving simulator
Rossi[93]	2011	Italy	Driving simulator
Baulk et al.[16]	2008	Australia	Driving simulator
Sagaspe et al.[94]	2008	France	Hospital, real-world driving
Ting et al.[95]	2008	Taiwan	Driving simulator
Park et al. [22]	2007	USA	Driving simulator
Vakulin et al.[18]	2007	Australia	Driving simulator

Reference	Year	Study Location	Setting
Moller et al. [96]	2006	Canada	Driving simulator
Akerstedt et al.[97]	2005	Sweden	Driving simulator
Arnedt et al.[20]	2005	Canada	Driving simulator
Otmani et al.[23]	2005	France	Laboratory (sleep center) with driving simulator
Philip et al.[21]	2005	France	Sleep laboratory, real highway driving, simulator
Philip et al.[98]	2003	France	Real-world driving and driving simulator
Thiffault and Bergeron[99]	2003	Canada	Driving simulator
Peters et al.[17]	1999	USA	Medical center, driving simulator
Lenne et al.[24]	1998	Australia	Driving simulator

Evidence Base Description

Key study design characteristics of the evidence base on driving ability are summarized in Table 14. One main differentiator is whether studies were experimental or observational/naturalistic. In experimental study designs, researchers either kept a single group of kept participants awake for an extended period of time and repeatedly measured their performance over time, or assigned participants to a certain duration of time in bed and assessed their performance the following day. The studies that assigned participants to a certain amount of time in bed to sleep at night were all crossover studies, so each participant completed both sleep-restricted and non-restricted conditions. Observational/naturalistic studies fitted cameras and other equipment onto vehicles and observed drivers and events during normal vehicle operation. In both types of studies, reported outcomes included total violations, crash (simulators only), lane deviation, driving-related reaction time, running off road, speeding or speed variability, tailgating, and a driving tracking task. To focus on acute fatigue in multi-day studies, we captured data from the first day after experimental sleep conditions.

Key study participant characteristics are summarized in Table 15. None of the studies assessed outcomes of motorcoach drivers. In all studies, drivers were selected for healthfulness, or at least considered medically fit for commercial driving by the U.S. Department of Transportation. Most (>95%) were men. Otherwise, the drivers were poorly characterized. Only one reported information on race/ethnicity. In the studies that reported it, most drivers were middle age. Information on years of experience was limited. In one study, over a third of drivers snored while sleeping, although none had a diagnosis of sleep apnea.[87]

The other studies addressed populations of healthy adult volunteers. Participants were generally selected for being young (mean or median age in 20s or 30s) and healthy, including not having any sleep disorders. The proportion of men ranged widely from about half to all. Driving experience was poorly characterized. Predisposing fatigue factors did not appear to be a potential confounding factor in any of these studies.

Table 14. Key Study Design Characteristics, Key Question 1b, Driving Ability

Reference	Year	Study Design	Risk of Bias	Study N	Data Collection Method	Sample Type	Comparison made (of interest)	Fatigue Type(s) Addressed	Outcomes Reported							
									All violations	Crash / Critical Events	Lane deviation	Reaction time	Running off road	Speed-related	Steering-related	Tailgating
Professional Drivers																
NTRCI / Fine et al. [87]	2012	Prospective cohort	Moderate	50	Experimental: driving simulator	Convenience (volunteer)	Sleepiness score, cohort divided	Naturalistic	✓	✓				✓		✓
Barr et al.[34]	2011	Single-arm time series, prospective	Moderate	41	Real-world driving	Convenience (volunteer)	Change over time driving, same group	Naturalistic			✓			✓		
Naturalistic Truck Driving Study[14, 15]	2011 2012	Single-arm time series, prospective	Moderate	97	Real-world driving	Convenience (volunteer)	Change over time driving, same group	Task-related		✓						
Kee et al. [88]	2010	Nonrandomized controlled trial, assessed as single-arm time series	Moderate	25	Experimental: driving simulator	Convenience (volunteer)	Change over time driving, same group	Task-related					✓	✓		
Mortazavi[89]	2009	Single-arm time series, prospective	Moderate	13	Experimental: driving simulator	Convenience (volunteer)	Change between rested and night session	Insufficient sleep		✓	✓			✓	✓	
Drowsy Driver Warning System Study[12, 13]	2007 2009	Single-arm time series, prospective	Moderate	103	Real-world driving	Convenience (volunteer)	Hour driven, same group	Circadian Task-related		✓						
Howard et al. [90]	2007	Randomized crossover, analyzed as single-arm time series	Moderate	16	Experimental: driving simulator	Convenience (volunteer)	Rested vs. extended wakeful (later that evening), same group	Insufficient sleep Circadian			✓			✓		

Reference	Year	Study Design	Risk of Bias	Study N	Data Collection Method	Sample Type	Comparison made (of interest)	Fatigue Type(s) Addressed	Outcomes Reported							
									All violations	Crash / Critical Events	Lane deviation	Reaction time	Running off road	Speed-related	Steering-related	Tailgating
Hanowski et al.[91]	2003	Single-arm time series, prospective	Moderate	42	Real-world driving	Convenience (volunteer)	Signs of fatigue, one group	Naturalistic		✓						
Commercial Motor Vehicle Driver Fatigue and Alertness Study[64]	1997	Single-arm time series, prospective	Moderate	80	Real-world driving	Convenience (volunteer)	Drive duration, same group	Task-related			✓					
Fuller[92]	1983	Single-arm time series, prospective	Moderate	NR	Real-world driving	NR	Change over time driving, same group	Task-related Circadian								✓
Nonprofessional Drivers																
Matthews et al. [19]	2012	Single-arm time series	Moderate	14	Experimental, driving simulator	NR	Change of duration of wakefulness in 28-hour days (23.3 hours sleep, 4.67 hours sleep)	Insufficient sleep			✓			✓		
Rossi et al.[93]	2011	Crossover	Moderate	17	Experimental, Driving simulator	Convenience (volunteers)	Morning vs. afternoon Environment Time on task	Task-related			✓				✓	
Baulk et al. [16]	2008	Single arm time series	Moderate	15	Experimental, driving simulator	Convenience (volunteers)	Duration of wakefulness, same group	Insufficient sleep		✓	✓			✓		
Sagaspe et al. [94]	2008	Cross-over	Moderate	14	Experimental Real driving	Convenience (volunteers)	Drive time and duration, 4 scenarios, same groups	Circadian			✓					

Reference	Year	Study Design	Risk of Bias	Study N	Data Collection Method	Sample Type	Comparison made (of interest)	Fatigue Type(s) Addressed	Outcomes Reported							
									All violations	Crash / Critical Events	Lane deviation	Reaction time	Running off road	Speed-related	Steering-related	Tailgating
Ting et al.[95]	2008	Single-arm time series, prospective	Moderate	30	Experimental, Driving simulator	Convenience (volunteers)	Time on task	Task-related		✓	✓			✓	✓	
Park et al. [22]	2007	Crossover	Moderate	14	Experimental, driving simulator Objective test	Convenience (volunteers)	Sleep duration, same groups all three conditions	Insufficient sleep			✓					
Vakulin et al. [18]	2007	Randomized cross-over	Moderate	21	Experimental, Driving simulator	Convenience (volunteers)	Rested vs. moderate sleep deprivation , same groups	Insufficient sleep		✓		✓			✓	
Moller at el. [96]	2006	Single-arm time series	Moderate	31	Experimental, driving simulator	Convenience (volunteers)	Task repetition, time of day, same group	Circadian			✓	✓		✓		
Akerstadt et al.[97]	2005	Crossover	Moderate	10	Experimental, Driving simulator	Convenience (volunteers)	Rested vs. coming off night shift	Circadian Insufficient sleep		✓						
Arnedt et al. [20]	2005	Single arm time series	Moderate	11	Experimental: driving simulator	Convenience (volunteer)	Change over time driving, same group	Insufficient sleep Circadian Task-related			✓		✓	✓		
Otmani et al. [23]	2005	Crossover	Moderate	14	Experimental, driving simulator	NR	Rested vs. sleep deprived, same groups all conditions	Insufficient sleep Circadian Task-related			✓				✓	
Philip et al.	2005	Randomized cross-	Moderate	12	Experimental ,	Convenience	Rested vs. sleep	Insufficient			✓					

Reference	Year	Study Design	Risk of Bias	Study N	Data Collection Method	Sample Type	Comparison made (of interest)	Fatigue Type(s) Addressed	Outcomes Reported							
									All violations	Crash / Critical Events	Lane deviation	Reaction time	Running off road	Speed-related	Steering-related	Tailgating
[21]		over			Driving simulator Real driving	(volunteers)	reduced, same groups	sleep								
Philip et al.[98]	2003	Crossover	Moderate	10	Experimental Driving simulator Road drive	Convenience (volunteers)	Rested vs. sleep deprived	Insufficient sleep				✓				
Thiffault and Bergeron[99]	2003	Crossover	Moderate	56	Experimental, Driving simulator	Convenience (volunteers)	Time on task Environment	Task-related							✓	
Peters et al. [17]	1999	Single arm time series,	Moderate	12	Experimental, Driving simulator	Convenience (volunteers)	Rested vs. sleep deprivation, same group	Insufficient sleep Circadian		✓						
Lenne et al.[24]	1998	Crossover	Moderate	24	Experimental, Driving simulator	Convenience (volunteers)	Rested vs. sleep deprived	Insufficient sleep			✓			✓		

NR -- Not reported

Table 15. Key Driver Characteristics, Key Question 1b, Driving Ability

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
Professional Drivers								
NTRCI / Fine et al. [87]	2012	Truck drivers	Age 21 to 65 years Valid state-issued CMV license Long-haul driver sleeping at least 3 nights weekly in their birth Medically fit per	Sleep apnea diagnosis Routine and habitual use of sedating or hypnotic medications, illicit drugs, or alcohol	98%	White: 56% African-American: 36% Hispanic: 6% Other: 2%	40.5 (8.2)	Mean 8.6 years

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
			USDOT Own cell phone Literate in English	Simulator sickness				
Barr et al.[34]	2011	Truck drivers Local/short haul drivers	NR	NR	Not reported	NR	NR	NR
Naturalistic Truck Driving Study [14, 15]	2011	Truck drivers 78% primarily long-haul 22% primarily line-haul	NR All drivers were professionals working with select companies.	NR	94%	NR	44 (Range 21-73) years	Mean 9.13 years (range 4 weeks to 54 years)
Kee et al. [88]	2010	Type of professional driver not reported	Professional driver Healthy (self-reported) No simulator sickness	None additional reported	100%	NR	Range: 23 – 53	At least 2 years
Mortazavi et al.[89]	2009	Truck drivers	Availability in area Valid CMV license No simulator sickness	None additional	85%	NR	41 (9.1) (Range 23-55)	NR
Drowsy Driver Warning System Study[12, 13]	2007 2009	Long-haul and line haul truck drivers	Drivers from three trucking companies who volunteered	NR	99%	NR	NR	NR
Howard et al. [90]	2007	Type of professional driver not reported, likely truckers because work for transport companies	Current driver's license 18 to 65 years old	Any medical contraindication to sleep deprivation or alcohol Sleep apnea diagnosis or symptoms Narcolepsy Insomnia Visual acuity problems Medications or illicit drugs that might affect performance Chronic sleepiness	95%	NR	Mean: 46.2 (10.7)	NR

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
Hanowski et al.[91]	2003	Truck drivers Local/short haul	Local/short haul drivers working for companies participating in research who volunteered	NR	100%	NR	31 (range 19-57)	NR
Commercial Motor Vehicle Driver Fatigue and Alertness Study[64]	1997	Truck drivers Long haul	At least one year experience driving Class 8 tractors No drugs No alcohol prior to trip No documented medical history of sleep disorder Pass physician exam	NR	100%	NR	Range 25-65; uniform distribution	Not reported. At least one year.
Fuller et al.[92]	1983	Truck drivers, independent and convoy drivers assessed separately	NR	NR	NR	NR	NR	NR
Nonprofessional Drivers								
Matthews et al. [19]	2012	Healthy young men	Non-smokers No shift work <2 cups coffee daily No sleep disorders No trans-meridian travel in last 3 months	NR	100%	NR	21.8 (3.8)	NR
Rossi et al.	2011	Drivers University students and staff, primarily	No previous driving simulator experience At least 3 years driving experience At least 5,000 km annual driving	NR	"Relatively balanced"	NR	25.5 (3.32) (Range 20-40)	6.5 (3.38) (Range 3-15)
Baulk et al. [16]	2008	Healthy adults	Driving at least 2 years Free from sleep disorders	NR	47%	NR	33.6 (11.1) Range: 22-56	At least 2 years

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
Sagaspe et al. [94]	2008	Healthy young men Drivers	Healthy	Any sleep disorder (determined by clinical assessment and a week of monitoring.)	100%	NR	23.4 (1.7) Range 21-25	NR
Ting et al.[95]	2008	Drivers Healthy young men	Healthy young men Licensed drivers Drove at least 400 km per year	Experience with simulator Health or sleep problems Habitual tobacco, alcohol, or caffeine use	100%	NR	22.1 (Range 20-26)	NR
Park et al. [22]	2007	Healthy younger adults Drivers	Normal health	High sleepiness scale score Stimulant or depressant medications Sleep disorders	50%	NR	Range 19 to 57 years	NR
Vakulin et al. [18]	2007	Healthy young men Drivers	Healthy Normal sleep scale and sleep quality index results	Any sleep disorder Extreme morning or evening types	100%	NR	22.5 (3.7) Range 18-30	At least 2 years' experience
Moller et al. [96]	2006	Healthy young adults Drivers	None reported	Abnormal sleep duration or quality on sleep screening questionnaires	68%	NR	31 (2)	NR
Akerstedt et al.[97]	2005	Night shift workers Drivers	Night shift workers	None reported	50%	NR	37 (12)	NR
Arnedt et al. [20].	2005	Healthy men, college students	Valid driver's license Regular sleep schedule Neither extreme morning nor evening type Good health Willingness to comply	Medications that could affect sleep/wake cycle	100%	NR	Range: 18 – 32	NR

Reference	Year	Population	Inclusion Criteria	Exclusion Criteria	Sex % Men	Race/Ethnicity	Age (Years) Mean (SD)	Years of Experience
			with the experiment					
Otmani et al. [23]	2005	Healthy younger men Drivers	None reported, but no participants had sleep disorders, medication, and were in good physical condition	NR	50%	NR	Range 25 to 55	NR, but generally had licenses for at least 10 years All drove at least 10,000 km/year
Philip et al. [21]	2005	Healthy young men Drivers	Healthy	Any sleep disorder	100%	NR	21.1 (1.6) Range: 19 – 24	NR Average 6563 (1950) miles driven per year
Philip et al.[98]	2003	Drivers	Healthy	Sleep disorder Sleep-wake schedule disorder	100%	NR	22 (18-24)	NR
Thiffault and Bergeron[99]	2003	Drivers Primarily university students and personnel	NR	NR	100%	NR	24	At least 2 years
Peters et al. [17]	1999	Healthy young adults Drivers	Normal vision Pass physical exam, drug test, mental exam Nonsmoker Low caffeine user No stimulants, including caffeine, through day	NR	50%	NR	Range 26 to 35 years	NR At least 8,000 miles driven annually
Lenne et al.[24]	1998	Drivers College area	Licensed drivers	Shift workers Extreme morning or evening type >6 cups coffee per day or equivalent	50%	NR	Range 18.7 to 32 years	NR

NR – Not reported

Risk of Bias Assessment

The risk of bias of the evidence base on driving ability was rated as moderate overall. Most studies were well controlled and factored out potentially bias influences on sleep or fatigue response, such as health conditions or baseline fatigue. Fatigue was experimentally induced in a controlled and supervised setting. Driving ability was always objectively measured.

Some factors negatively impacted the risk of bias rating, however. None of the controlled studies masked participants or assessors to group allocation. While this may not be feasible in these studies, lack of masking remains a potential source of bias because it is possible that psychological factors related to knowledge of sleep deprivation status may have affected performance. Consequently, these studies were not rated as 'low' risk of bias. The time-series studies enrolled volunteers and did not base the sample on a random or pseudo-random sampling method. There may be differences between volunteers and the general population on the whole. Further, although the researchers used experimental methods to design the single-arm time series, the influence of confounding factors cannot be ruled out because there were not control or comparison groups. For these two reasons, the risk of bias was never rated as 'low.'

The summary of findings and instruments used are shown in Table 16. Full itemized assessment for every study is provided in Appendix E.

Table 16. Risk of Bias Assessment for Key Question 1B: Driving Ability

Reference	Year	Scale Used	Risk of Bias
Professional Drivers			
NTRCI / Fine et al. [87]	2012	Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)	Moderate
Barr et al.[34]	2011	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Naturalistic Truck Driving Study[14, 15]	2011	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Kee et al. [88]	2010	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Mortazavi et al.[89]	2009	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Drowsy Driver Warning System Study[12, 13]	2007 2009	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Howard et al. [90]	2007	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Hanowski et al.[91]	2003	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Commercial Motor Vehicle Driver Fatigue and Alertness Study[64]	1997	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Fuller[92]	1983	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Non-Professional Drivers			
Matthews et al. [19]	2012	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Rossi et al.[93]	2011	JBI Controlled Trial Instrument	Moderate
Baulk et al. [16]	2008	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Sagaspe et al. [94]	2008	JBI Controlled Trial Instrument	Moderate
Ting et al. [95]	2008	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Park et al. [22]	2007	JBI Controlled Trial Instrument	Moderate
Vakulin et al. [18]	2007	JBI Controlled Trial Instrument	Moderate

Reference	Year	Scale Used	Risk of Bias
Moller et al. [96]	2006	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Akerstadt et al.[97]	2005	JBI Controlled Trial Instrument	Moderate
Arnedt et al. [20]	2005	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Otmani et al. [23]	2005	JBI Controlled Trial Instrument	Moderate
Philip et al. [21]	2005	JBI Controlled Trial Instrument	Moderate
Philip et al.[98]	2003	JBI Controlled Trial Instrument	Moderate
Thiffault and Bergeron[99]	2003	JBI Controlled Trial Instrument	Moderate
Peters et al. [17]	1999	JBI Descriptive / Case-series Risk of Bias Assessment Tool	Moderate
Lenne et al.[24]	1998	JBI Controlled Trial Instrument	Moderate

Generalizability of Evidence Base to Motorcoach Drivers

The generalizability of this evidence on driving ability to real-world motorcoach drivers is poor. No studies presented data on motorcoach drivers. The professional driver studies primarily enrolled truck drivers, who may have relatively similar stressors that affect sleep debt and need for rest, such as insufficient sleep, driving overnight, and similar driving tasks and related fatigue. Data from the evidence base used to address Key Question 3 suggest that truck drivers typically drive more miles per week than motorcoach drivers, so it is possible truck drivers are more acclimated to coping with task-related fatigue; on the other hand, they may have more underlying sleep debt. The flexibility for break location and duration of truck drivers compared to motorcoach drivers probably varies considerably, depending on schedule and route.

The remaining studies enrolled volunteers highly selected for healthiness and absence of sleep issues. These participants are likely much healthier than the average motorcoach driver (or anyone randomly selected from the general population). In addition, these volunteers are much younger than the average motorcoach driver. Key Question 3 reports that the median age of motormotorcoach/bus drivers is in the late 40s, and that few motorcoach drivers are under the age of 24. In this evidence base, most studies reported mean or median age in the 20s and 30s. Finally, the volunteers probably do not face the same work stresses as motorcoach drivers, such as long driving hours and shift work, and so may be less likely to have an underlying element of fatigue that could affect response to experimentally-induced acute fatigue or test conditions. On the other hand, they might be less acclimated to coping with fatigue while driving than more experienced drivers.

The naturalistic/observational studies are relevant to the populations they represent, but the experimental studies may provide less direct evidence. Experimental study conditions may also limit generalizability to real-world motorcoach driving. Non-pathologic fatigue tends to be experimentally induced by forced wakefulness or restricted sleep, and how comparable this is to driving fatigue is unclear. In addition, the duration of drivers in the simulated test settings is generally short, as short as 10 minutes, so the effect of task fatigue is not addressed by most of these studies. Finally, performance on simulated driving may not be the same as performance on real driving. One study in this evidence base found that real and simulated driving measured line crossing similarly, but reaction time was slower and feelings of sleepiness were greater in the simulator.[21]

Findings

Included studies were divided by professional and nonprofessional drivers before analysis to present the most relevant information first and because this variable was expected to be an important influence on driving ability under fatiguing experimental conditions. A narrative synthesis of findings is presented in the following text. For further information, refer to the tables that follow. Table 17 shows data on professional drivers, and Table 18 shows data on nonprofessional drivers.

Motorcoach Drivers

No included studies address the role of non-pathologic fatigue on driving ability in motorcoach drivers.

Other Commercial Motor Vehicle Drivers

Evidence suggests critical event rates increase over 11-hour driving shifts. *(Strength of Evidence: Minimally Acceptable)*

No other specific conclusions are possible because each of the studies report different outcomes for the same general area of fatigue assessment; however, in general, the studies suggest fatigue impairs driving ability.

Insufficient Sleep

Simulated Crash. Mortazavi et al.,[89] 2009, assessed driving performance in simulated drives in 13 professional truck drivers shortly after awakening from a full night's rest in the morning and again in the evening 17 to 18 hours later. They found the incidence of crash to be significantly higher in the evening, and that most drivers who crashed had run off the "road."

Lane Deviation. Two studies assessed the ability to stay in lane, but only one drew a conclusion on this outcome. Howard et al., 2007[90], assessed driving performance during a 30-minute simulation in 16 transportation drivers with insufficient sleep due to extended experimental wakefulness at 7 p.m., 8:30 p.m., 10 p.m., 1 a.m., and 3 p.m. Lane deviation increased at each assessment, but the differences were not statistically significant. Mortazavi et al. described above in *Simulated Crash*, found both duration of time in lane departure and variability of lane displacement significantly higher (eg, more impaired) in the evening session.

Speed. Howard et al., 2007[90], also assessed speed variation out of the prescribed range and found it increased by less than one kilometer per hour on average at later assessment times, but did not observe statistically significant differences. Mortazavi et al. assessed mean and standard deviation of speed and acceleration, finding outcomes were significantly different when fatigued. Although both studies suggest insufficient sleep does not significantly impair speed regulation, it is not possible to rule out the possibility that there is a relationship because these small studies may have been underpowered to detect an effect.

Steering. Mortazavi et al. did not find steering (measured in mean degrees) was significantly different in the evening assessment, but did find that the standard deviation of steering wheel movement was significantly higher at night.

Circadian Factors

Critical Event Rate. The Drowsy Driver Warning System Study measured real-world critical events and opportunities for critical events in a group of 98 truck drivers over 11 hours of driving during a 24-hour period.[12] The authors reported that the rate of critical events was higher between 7 a.m. and 6 p.m., and highest between 7 a.m. and 8 a.m. and 5 p.m. and 6 p.m. The authors noted that time of day and traffic density were statistically associated.

Task-related

Critical Event Rate. Two naturalistic studies of truck drivers, the Drowsy Driver Warning System Study (n=99)[12, 13] and the Naturalistic Truck Driving Study (n=97)[14, 15] assessed the critical event rate (events per opportunity) over 11 hours of driving. The Drowsy Driver Warning System Study found that the rate was statistically significantly higher at hours 2 through 11, compared to the first hour of driving. The Naturalistic Truck Driving Study found the safety critical event increased by the hour, and the authors concluded this represented a time-on-task effect. Neither study found a statistically significant increase in event rate between the 10^{th} and 11^{th} hour.

Various Outcomes. Each of the other studies that addressed the effects of task-related fatigue addressed different outcomes and how those outcomes changed over time. The Commercial Motor Vehicle Driver Fatigue and Alertness Study (n=80)[64] assessed lane deviation over routes of varying length, and reported that while lane tracking appeared better in 10-hour routes than 13-hour routes, the authors could not attribute this to reduced trip time. Kee et al., 2010[88], assessed 25 professional drivers on a 250 kilometer simulated course and found that the running-off-the-road index (amplitude of exit per second) and speed variation of greater than 20 km/hour both increased significantly over drive time and was significantly higher at later measurement times than during the first 10 minutes of the drive. Fuller, 1983[92], assessed real-world truck driving performance over 11-hour shifts for four consecutive days and found that following distance (eg, tailgating) was best on the late shift, during the first hour of driving and during the last hour of driving, except for convoy drivers, who on the late shift had poorer outcomes toward the end of their shifts. Fuller concluded that eight or nine hours of driving was a threshold for fatigue effects while driving.

Naturalistic

In the remaining studies, the relationship between driving ability and fatigue or sleepiness was investigated, but the cause or potential causes of fatigue were not experimentally induced, stated, or clearly determinable. Various outcomes were reported by one study each, and the findings were not generally consistent.

Various Outcomes. Fine et al., 2012[87], found that during simulated drives by 50 professional truck drivers, total mean Epworth Sleepiness Scale (ESS) score was not associated with collisions or speeding by more than 15 miles per hour, but greater sleepiness was associated with tailgating and rate of total violations. Hanowski et al., 2003[91], investigated real-world near crashes in which a long- or short-haul truck driver was at fault, concluding that fatigue contributes to the occurrence of these events, and may be particularly important for younger drivers. Barr et al., 2011[34], assessed performance during real-world driving among 41 long or short-haul truck drivers and did not find an association between signs of fatigue and speed variation. They stipulated that the equipment used was too insensitively to measure another outcome of interest, lane deviation, satisfactorily.

Non-professional Drivers

Evidence suggests insufficient sleep leads to greater incidence of crash *(Strength of Evidence: Moderate)*, and that it is associated with decreased ability to drive within lane *(Strength of Evidence: Strong)*. Other measures of driving ability were addressed by fewer studies with less consistent findings; this evidence was insufficient to support evidence-based conclusions.

Insufficient Sleep

Simulated Crash. Three studies assessed the influence of insufficient sleep on simulated crash in healthy adults, and all found that with less sleep or longer duration since last sleep, crash was more common. Baulk et al., 2008[16], kept 15 adults up for 26 hours of supervised wakefulness, and they had only one or two collisions per simulated drive except for between hours 24 and 26, when they had 25. The other two studies subjected the volunteers to sleep restriction and then measured crash frequency during driving simulation at the afternoon circadian nadir, starting at 2 p.m. Peters et al., 1999[17], found the mean crash incidence was higher after only 4 hours in bed the previous night than after non-deprived sleep the preceding day. Vakulin et al., 2007[18], and colleagues found that significantly more of their 21 drivers crashed after 4 hours in bed than after 8.5 hours in bed.

Lane Position or Deviation. Seven studies assessed the relationship between insufficient sleep and lane deviation in healthy adult volunteers. Insufficient sleep was experimentally induced by either prolonging wakefulness or assigning reduced time in bed. These studies consistently found that increased wakefulness or time in bed restricted to less than four hours was associated with greater lane deviation.

Among studies that kept drivers up for prolonged wakefulness and repeatedly measured lane deviation, all found deterioration. Baulk et al. kept 15 adults awake for 26 hours and found that lane drifting increased significantly with duration of wakefulness and was higher at each time the drive was repeated during increasingly extended wakefulness. Matthews et al., kept 14 young men awake for 22 hours and found that during 10-minute drives taken between 2 and 22 hours of wakefulness, lane drifting was not significantly different.[19] However, the number of times the center of the car left the road or struck a vehicle it was passing significantly increased over time. Arnedt et al. measured performance over 30-minute drives at 2:30 a.m., 5 a.m., and 7:30 a.m. after a normal day among 29 young healthy college students, and found that with increased time awake, lane deviation increased at each session, and increased faster during later sessions.[20].

The four studies that restricted time in bed to four hours or less found impairment in lane tracking, which was most pronounced at durations of time in bed of less than four hours. Philip et al., assigned 14 healthy young men to 2 hours in bed one night and 8 another night, finding that during real or simulated drives of over 100 miles repeated throughout the following day, there were more inappropriate line crossings after 2 hours in bed but that performance did not deteriorate throughout the day for either group.[21] Park et al., assigned 14 healthy young adults to 0, 4, and 8 hours of sleep before a 60-minute simulation drive and found lane deviation was worse when the participants had no sleep, but it was not significantly different when they had 4 hours compared to 8 hours.[22] Otmani et al., tested healthy men in a 90-minute simulation between 2 p.m. and 4 p.m. after no sleep deprivation or only 4 hours in bed. They did not find a significant difference between groups at any one time point, but did find a significant difference overall in a repeated measures analysis.[23] Lenne et al., 1998[24], compared performance after sleep deprivation or normal night's sleep in 24 college students at 8 a.m., 11 a.m., 2 p.m., 5 p.m., and 8 p.m., and found that sleep-deprived drivers drove more laterally, but within acceptable boundaries. They noted that changes during the day or within sessions were not significant.

Lane Deviation Variability. Five of the studies described above, Matthews et al., [19], Arnedt et al.[20], Otmani et al., [23], Park et al.[22], and Lenne et al.[24], also assessed lane deviation variability, defined as the standard deviation of lane position. All found that experimentally induced insufficient sleep significantly increased lane deviation variability.

Running off the Road. One of the studies described above, Arnedt et al. [20], also found increased time awake increased the number of times the driver ran off the road, and that the frequency of running off the road increased more quickly at later assessment times.

Braking Time. Two studies previously described, Vakulin et al.,[18], and Philip et al., 2003[98], assessed the influence of sleep restriction on braking time. Vakulin et al. did not find braking time was significantly slower after 4 hours in bed (vs. 8.5), but Philip et al. did find braking time was significantly slower after 2 hours in bed (vs. 8.5). These results are not necessarily inconsistent because the sleep restriction condition differs.

Speed Deviation, Speed Variability, Speed Violations. Baulk et al.,[16], Matthews et al.[19] also measured speed deviation, but only Baulk et al. reported statistically significantly greater speed deviation with less sleep. Lenne et al.,[24], assessed mean speed, reporting sleep deprivation was associated with reduced ability to drive at assigned speed. Matthews et al. did not find significantly greater speed variability (standard deviation of speed deviation) either, but Arnedt, [20], did find deterioration in variability and faster deterioration with longer durations of wakefulness. Lenne et al. [24], found that with sleep deprivation drivers had significantly greater speed variation overall and at 8 a.m. and 2 p.m., but not within drive sessions. Just as Matthews et al. did not find significant differences in speed deviation or variability, Lenne et al. did not find differences in incidents of speeding.

Steering Deviation, Steering Wheel Movements Vakulin et al. collected data on steering deviation during their study and found that the difference between the sleep deprived and regular sleep conditions was not significantly different at any time point or overall.[18] Otmani et al. measured steering wheel movement and amplitude during their study and reported no significant differences in either outcomes.[23]

Circadian Effects

Afternoon, multiple measures. Moller and colleagues assessed simulated driving performance in 31 healthy young adults and 10 am, noon, 2 pm, and 4 pm.[96] They did not find any differences through the day for lane deviation, lane deviation variability, or road position. They did find reaction time was statistically significantly slower between 10 a.m. and each of the subsequent time points, and that speed deviation was statistically significantly greater between 10 a.m. and 2 p.m. and between 10 a.m. and 4 pm.

Early morning, multiple measures. Two studies assessed the early morning circadian lull. Sagaspe et al.[94] measured real-world lane deviation in 14 healthy young men at during drives between 9 a.m. 10 p.m. 1-5 a.m., 3-5 a.m., and a longer drive between 9 p.m. and 5 a.m. The number of inappropriate line crossings in the last hour of every overnight/early morning drive was statistically significantly higher than the reference drive. Ingre et al, 2006[100], conducted a simulated driving study of 10 night-shift workers after their shifts, finding simulated crashes and incidents were significantly more frequent than in the rested comparison (in which the same drivers slept before taking the test at the same time of day, rather than going to work). The workers reported being sleepier after driving, and in a post-hoc analysis the time of day was not a significant predictor of crash or other incidents. In this study, insufficient sleep appears to have been more important than circadian factors.

Task-related

Crash; Following Distance; Lane Position and Variation; Speed. These outcomes are grouped together here because only one study addresses them: Ting et al., 2008[95]. Ting et al. assessed crash during simulated 90-minute drives starting at 2:30 p.m. among 30 healthy young men. It found that crash incidence did not vary significantly by drive time. Ting et al. also assessed following distance, inappropriate lane crossings and lateral position variation, and speed variation, finding these measures varied significantly with time, particularly during the last 10 minutes compared to the first 10 minutes.

Steering. Although Ting et al. found significant deterioration in most driving ability outcomes (aside from simulated crash) with longer drive time, it did not find a significant difference in steering wheel movement. Thiffault and Bergeron compared the steering wheel variation in 56 university students in a simulated 40-minute monotonous drive and a 40-minute varied drive, and found that steering wheel movement and variation increased over time during each drive in both conditions, but did not significantly differ between them.

Multiple, Combined. Rossi et al., 2011[93], compared the performance of 17 drivers in a monotonous driving condition and a varied driving condition, finding that driving was poorer in afternoon drives and in the monotonous conditions. The index of driving ability included mean and standard deviation of lateral position and steering error.

Table 17. Key Question 1, Driving Ability: Comparisons and Findings: Professional Drivers

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Insufficient sleep	Crash (simulator)	Truck CMV drivers	Same group rested and later in day	After a full night's rest, baseline drive data was conducted 1-2 hours after waking, and fatigued condition was collected 17-18 hours later		The incidence of crash was significantly higher in the evening session, and potentially confounding variables such as speed were not correlated Most drivers who crashed did so after running off the road	**Mortazavi et al.[89]**	2009
Insufficient sleep Circadian: overnight	Lane deviation	Transportation professional drivers	Different durations of wakefulness, same group	Repeated measures of 30 minute drive over time as drivers became fatigued, at 7 pm, 8:30 pm, 10 pm, 1 am, 3 a.m. (n=16)		When participants were not sleep deprived, variation in lane position was about 43 at 7 p.m. and 49 at 8:30 pm. At 1 am, it was 52, and at 3 a.m. it was nearly 60. These data were estimated from a figure. This increase was not statistically significant.	**Howard et al. [90]**	2007
Insufficient sleep	Lane departure, Lateral displacement variation	Truck CMV drivers	Same group rested and later in day	After a full night's rest, baseline drive data was conducted 1-2 hours after waking, and fatigued condition was collected 17-18 hours later		Duration of time in lane departure was significantly higher in the later time, 2.4 (2.24) vs. 72.3 (23.96) seconds. The variability of lane displacement was also significantly higher, 0.36 (0.02) vs. 0.60 (0.06) meters	**Mortazavi et al.[89]**	2009
Insufficient sleep	Speed: variation (out of prescribed range)	Transportation professional drivers	Different durations of wakefulness, same group	Repeated measures of 30 minute drive over time as drivers became fatigued, at 7 pm, 8:30 pm, 10 pm, 1 am, 3 a.m. (n=16)		When participants were not sleep deprived, speed variation was about 2 km/hr at both 7 p.m. and 8:30 pm. At 1 am, it was about 2.5, and at 3 am, it was about 3. These data were estimated from a figure. This increase was not statistically significant.	**Howard et al. [90]**	2007
Insufficient sleep	Speed measures, various	Truck CMV drivers	Same group rested and later in day	After a full night's rest, baseline drive data was conducted 1-2 hours after waking, and fatigued condition was collected 17-18 hours later		The following were not significantly different between rested and tired conditions: Mean speed in km/h: 103.8 (2.36) vs. 110.8 (2.87) Mean acceleration in meters per second: 0.01 (0.01) vs. -0.04 (0.04) Standard deviation of speed in km/hr: 0.58 (0.09) vs. 0.52 (0.09) Standard deviation of mean acceleration in m/s: 0.13 (0.03) vs. 0.16 (0.05)	**Mortazavi et al.[89]**	2009

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Insufficient sleep	Steering Steering variation	Truck CMV drivers	Same group rested and later in day	After a full night's rest, baseline drive data was conducted 1-2 hours after waking, and fatigued condition was collected 17-18 hours later		Mean steering in degrees was not significantly different between morning and night test sessions: 0.30 (0.08) vs. 0.21 (0.08) However, the standard deviation of steering wheel movement was significantly higher in the fatigued session, 5.80 (0.3) vs. 7.60 (0.28).	**Mortazavi et al.[89]**	2009
Circadian effects	Critical events[b]	Truck CMV drivers	Same group over time	Critical events / opportunities over 11 hours driving (n=98)		The rate of critical events (incidents per opportunity) in which the participating driver was determined to be at fault was measured over 24 hours. The rate was highest between 7 a.m. and 6 pm, with high points between 7 and 8 and a.m. 5 and 6 pm. Time of day was statistically associated with traffic density: they increased and decreased together.	**Drowsy Driver Warning System Study[12]**	2009
Task-related	Critical events[b]	Truck CMV drivers	Same group over time	Critical events / opportunities over 11 hours driving (n=98)		In critical events for which the CMV driver was judged to be at fault, the rate (events/opportunity) was significantly higher at every driving hour from 2 to 11 hours compared to the first hour. The difference between hours 10 and 11 was not significantly different. The rate (hour) were: 0.026 (1); 0.014 (2); 0.017 (76); 0.013 (4); 0.015 (5); 0.016 (6); 0.015 (7); 0.015 (8); 0.016 (9); 0.012 (10); 0.015 (11). This pattern was also observed for only drivers who drove into the 11^{th} hour and other sensitivity analyses. When only baseline and control conditions were considered (no warning system for drowsy driving used), the difference from the first hour was not always statistically significant.	**Drowsy Driver Warning System Study[12, 13]**	2009
Task-related	Safety critical events[a]	Truck CMV drivers	Same group over hours driven	Event rate measured hourly for first 11 hours of shift (n=97)		The hourly rate of safety critical event (per driving hour) was: 0.12 (1); 0.125 (2); 0.125 (3); 0.17 (4); 0.165 (5); 0.165 (6); 0.195 (7); 0.15 (8); 0.155 (9); 0.175 (10); 0.23 (11). Data estimated from figure. The authors concluded that there was an overall time-on-task effect. However, they expected by did not find a statistically significant difference between hours 10 and 11 (although the raw data do show an increase). The rate for the 11^{th} hour was statistically significantly higher for only hours 1 and 2.	**Naturalistic Truck Driving Study[14, 15]**	2011 2012
Task-related	Lane tracking	Truck drivers	Same group, different trip duration	Lane deviation for all drivers on different route lengths (n=80)		Lane tracking did appear better in the 10 hour trips than the 13 hour trips, but researches did not conclude this was due to reduced trip time.	**Commercial Motor Vehicle Driver Fatigue and Alertness**	1997

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
							Study[64]	
Task-related	Running off road index (amplitude of exit per second)	Professional drivers	Same groups over time	Change in variable over 250 km drive course (n=25)		The driving performance index of RORI increased statistically significantly over drive time. Post hoc test showed a significant difference in effect of driving times. For last 10 minute epoch, RORI was significantly higher than that for the first 10 minutes period (p< .0001)	**Kee et al. [88]**	2010
Task-related	Speed: variation, large (>20 km/h, penalty per second)	Professional drivers	Same groups over time	Change in variable over 250 km drive course (n=25)		Large speed variation increased statistically significantly over time. Post hoc test for LSV showed a significant difference in effect of driving times: LSV index at 8th epoch (80 minutes) was significantly higher than first 10 minute (p< .001). Difference in mean between first epoch and eighth epoch was 196.32.	**Kee et al. [88]**	2010
Task related, Circadian (late)	Following distance ("headway time")	Truck drivers	Same group over hours driven	Drivers drove 11 hours for 4 consecutive days		Drivers had better performance (in terms of maintaining following distance) on late shift, during first hour of driving, and during last hour of driving (especially for older drivers on late shift). Convoy drivers on the late shift had poorer performance toward the end of their shifts in driving performance and drowsiness The authors concluded that 8 or 9 hours of driving was a threshold for fatigue effects while driving.	**Fuller[92]**	1983
Naturalistic	Crash	Truck drivers	Same groups, compared by sleepiness scale score	Performance during simulated drive, all drivers (n=50)		Total ESS score was not associated with simulator collisions (1.064, 95% CI: 0.944 to 1.198).	**NTRCI / Fine et al. [87]**	2012
Naturalistic	Near crash	Long and short haul truck drivers	None	Observation during natural driving, all drivers		Of 214 critical incidents, 77 were determined to be the truck driver's fault and in 16 of those, fatigue played a role. The authors concluded that fatigue contributes to safety critical events. They also noted younger drivers were more likely to show signs of fatigue before incident.	**Hanowski et al.[91]**	2003
Naturalistic	Lane deviation	Long and short haul truck drivers	Fatigue level	Performance during actual driving, all drivers (n=41)		The authors note that the study equipment used captured severe deviations well but not minor variations. 19 of 41 drivers were rated as impaired drivers while fatigued, and while unclear in the text this appears to be due to lane deviations.	**Barr et al.[34]**	2011

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Naturalistic	Speed deviation	Long and short haul truck drivers	Fatigue level	Performance during actual driving, all drivers (n=41)		No association between objectively assessed fatigue and speed variation was determined.	**Barr et al.[34]**	2011
Naturalistic	Tailgating	Truck drivers	Same groups, compared by sleepiness scale score	Performance during simulated drive, all drivers (n=50)		Total Epworth Sleepiness Scale (ESS) score was associated with tailgating (RR 1.026, RR 1.001 to 1.051).	**NTRCI / Fine et al. [87]**	2012
Naturalistic	Speed: Speeding (>15 mph)	Truck drivers	Same groups, compared by sleepiness scale score	Performance during simulated drive, all drivers (n=50)		Total ESS score was not associated with speeding (RR 1.07, 95% CI: 0.940 to 1.001)	**NTRCI / Fine et al. [87]**	2012
Naturalistic	All violations	Truck drivers	Same groups, compared by sleepiness scale score	Performance during simulated drive, all drivers (n=50)		Total ESS score was associated with an increase in all violations rate (RR 1.029, 95% CI 1.002 – 1.056)	**NTRCI / Fine et al. [87]**	2012

[a] Critical events include crashes, curb strikes, near-crashes, crash-relevant conflicts, and unintentional lane deviations, and anything else likely to cause safety event. Most events were unintentional lane deviations or crash-relevant conflicts

[b] Critical events included crashes, tire strikes, near crashes, and (predominantly) crash-relevant conflicts

Table 18. Key Question 1, Driving Ability: Comparisons and Findings: Non-professional Drivers

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Insufficient sleep	Crash	Healthy adults	Duration of time awake	26 hours of supervised wakefulness (n=15)		Collision with another object or vehicle Mean value at duration of wakefulness: 4-6 hours:1 8-10 hours: 2 18-20 hours: 1 24-26 hours: 25 These differences were not statistically significant.	**Baulk et al. [16]**	2008
Insufficient sleep Circadian: Mid-afternoon task	Crash	Healthy young adults	Sleep duration	First day no deprivation, second day 4 hours sleep, 12 hours continuous wakefulness (n=12)		Simulator drive 40 minutes, between 2 and 4 pm Crash increased on day 2 but was not statistically significantly different. The incidence was low; both data points appeared to be zero on the figure.	**Peters et al. [17]**	1999
Insufficient sleep	Crash	Healthy young men	Amount of overnight sleep	4 hours in bed (n=21) (crossover)	8.5 hours in bed (n=21) (crossover)	Driving task was 70 minutes and started at 2 pm 4.7% of control and 19% of sleep-restricted participants crashed.	**Vakulin et al. [18]**	2007
Insufficient sleep	Lane deviation	Healthy adults	Duration of time awake	26 hours of supervised wakefulness (n=15)		Measured from 0%, off road to right, to 100%, off road to left Mean value at duration of wakefulness, estimated from figure: 4-6 hours: 19 8-10 hours: 40 18-20 hours:45 24-26 hours: 110 There was statistically significantly more lane drifting incidents as duration of wakefulness increased.	**Baulk et al. [16]**	2008
Insufficient sleep	Lane deviation	Healthy young men	Multiple measures during time awake	Performance during 10-minute simulated drive at wakefulness from 2 hours to 22 hours (n=14)		Mean lane position defined as meters from center or car to road verge. It ranged from 0 at baseline to a high of about 0.015 at 14.5 and 17 hours. The differences were not statistically significant. The data were estimated from a figure.	**Matthews et al. [19]**	2012
Insufficient sleep	Lane violation	Healthy young men	Multiple measures during time awake	Performance during 10-minute simulated drive at wakefulness from 2 hours to 22 hours (n=14)		Number of times the center of the car left the road or contacted a vehicle it was passing, also referred to as lane violations. This was about zero at 2 hours, climbed steadily to about 0.05 at 9.5 hours, dropped to zero at 12 hours, and then climbed steadily to about 0.05 at 14.5 hours, 0.15 at 17 hours, 0.25 at 19.5 hours, and 0.3 at 22 hours. This difference was statistically significant. The data were estimated from a figure.	**Matthews et al. [19]**	2012

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Insufficient sleep	Lane deviation	Healthy younger adults	Sleep duration, same groups all three conditions	In separate sessions, all patients (n=14) completed each condition: sleep for 0, 4, or 8 hours, and next day perform 60 minute driving simulation task.		Critical Tracking Test measures duration driver can keep 'car' in 'lane.' The mean scores and standard deviations were 3.4 (0.33) in the 8 hour condition, 3.27 (0.526) in the 4 hour condition, and 2.85 (0.440) in the 0 hour condition. Differences were statistically significantly different between the 0 hour group and both the 4 hour and 8 hour sleep group, but not between the 8 and 4 hour group.	**Park et al. [22]**	2007
Insufficient sleep Circadian: Mid-afternoon task	Lane deviation	Healthy men	Change over 90 minute drive time, and group comparison	No sleep deprivation (n=20, crossover)	Overnight sleep deprivation (4 hours sleep 3 a.m. – 7 am) (n=20, crossover)	Testing between 2 and 4 pm As estimated from a figure, in the first 10 minutes, the mean for the rested was about 1.75, and the sleep deprived was about 1.25. It began to rise in both groups after about 40 minutes, and at the study finish was about 4 for the sleep deprived and 2.5 for the rested group. The difference between groups at any time point was not significantly different. However, the authors reported that in the overall ANOVA analysis is was statistically significantly higher after sleep deprivation.	**Otmani et al. [23]**	2005
Insufficient sleep	Lane deviation	Healthy young men	Sleep duration, crossover	2 hours in bed overnight (n=14) (crossover)	8 hours in bed overnight (n=14) (crossover)	Real drive: 125 miles round trip (105 minutes) repeated 6 times during day Simulated drive: 105 minute course, started at same times as real drives For both tasks there were statistically significantly more inappropriate line crossings for the sleep-deprived group. Performance did not deteriorate through the day.	**Philip et al. [21]**	2005
Insufficient sleep Circadian - overnight Task-related	Lane deviation	Young healthy college students	Duration of time awake	Performance during 30 minute simulated drive over time after a normal day, midnight, 2:30 am, 5 am, and 7:30 a.m. (n=29)		With increased time awake, the drivers drove statistically significantly increasingly to the left of the center of their lane. Also, it was statistically significantly worse at 7:30 than at the previous assessments. Deterioration during the drive was statistically significantly faster at the later assessment times.	**Arnedt et al. [20].**	2005
Insufficient sleep	Lane position, mean	Drivers, recruited from college campus	Sleep amount	Sleep deprivation (n=24, crossover)	After normal night's sleep (n=24, crossover)	20 minute simulated drives at 8 am, 11 am, 2 pm, 5 pm, and 8 pm. Under the sleep-deprived condition, drivers drove closer to midline but remained within acceptable boundaries. During the day and within sessions drivers drove more laterally, but this effect was not statistically significant.	**Lenne et al.[24]**	1998
Insufficient sleep	Lane position, standard deviation (variability)	Drivers, recruited from college campus	Sleep amount	Sleep deprivation (n=24, crossover)	After normal night's sleep (n=24, crossover)	20 minute simulated drives at 8 am, 11 am, 2 pm, 5 pm, and 8 pm Sleep deprivation had greater position variability Variability decreased across the day Performance was best at 5 and 8 pm Within each session, performance deteriorated over time statistically significantly.	**Lenne et al.[24]**	1998

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Insufficient sleep	Lane deviation variability	Healthy young men	Duration of time awake	Performance during 10-minute simulated drive at wakefulness from 2 hours to 22 hours (n=14)		Lane position variability is the standard deviation of lane position measurements, in meters. This value was 0 at 2 hours, -0.02 at 4 hours, and then ranged between about -0.01 to 0.01 through 14.5 hours. Thereafter, it climbed to about 0.04 at 17 hours and 19.5 hours, and 0.05 at 22 hours. This difference was statistically significant. The data were estimated from a figure.	**Matthews et al. [19]**	2012
Insufficient sleep Circadian - overnight Task-related	Lane deviation variability	Young healthy college students	Duration of time awake	Performance during 30 minute simulated drive over time after a normal day, midnight, 2:30 am, 5 am, and 7:30 a.m. (n=29)		With increased time awake, variability of tracking increased statistically significantly. Also, it was statistically significantly worse at 7:30 than at the previous assessments. Deterioration during the drive was statistically significantly faster at the later assessment times.	**Arnedt et al. [20].**	2005
Insufficient sleep Circadian: Mid-afternoon task	Lane deviation variability	Healthy men	Change over 90 minute drive time, and group comparison	No sleep deprivation (n=20, crossover)	Overnight sleep deprivation (4 hours sleep 3 a.m. – 7 am) (n=20, crossover)	Testing between 2 and 4 pm The standard deviation of lateral position did not significantly differ by sleep deprivation but was statistically significantly higher with increased drive time, during the last five drive periods.	**Otmani et al. [23]**	2005
Insufficient sleep	Lane deviation variability	Healthy younger adults	Sleep duration, same groups all three conditions	In separate sessions, all patients (n=12) completed each condition: sleep for 0, 4, or 8 hours, and 60 minute driving simulation task.		Lane deviation was measured as the standard deviation of the lateral lane position during 60-minute driving task. A statistically significant main effect was found when analysis was performed as 6 one-way within-subjects ANOVA every 10 minutes. At each time point, the 8 and 0 hour sleep condition results were statistically significantly different. The 8 and 4 hour condition results were statistically significantly different at every time marker except for the last, 60 minutes (the 4 hour group improved at this time point). The 4 and 0 hour group had statistically significant differences at 10 and 60 minutes but no time point in between. Mean scores were always highest in 0 hour group (overall range 1.75 to 2.5), intermediate in the 4 hour group (overall range 1.25 to 1.75), and lowest in the 8 hour group (overall range 1.0 to 1.2), as estimated from a figure.	**Park et al. [22]**	2007
Insufficient sleep	Running off road	Young healthy	Duration of	Performance during 30 minute simulated drive over		With increased time awake, the number of times drivers drove off the road increased statistically significantly. Deterioration during the drive	**Arnedt et al. [20].**	2005

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
Circadian - overnight Task-related		college students	time awake	time after a normal day, midnight, 2:30 am, 5 am, and 7:30 a.m. (n=29)		was statistically significantly faster at the later assessment times.		
Insufficient sleep	Braking reaction time	Healthy young men	Amount of overnight sleep	4 hours in bed (n=21) (crossover)	8.5 hours in bed (n=21) (crossover)	Driving task was 70 minutes and started at 2 pm Mean brake time in seconds was 1.15 in the control group and 1.27 in the sleep-restricted group (as estimated from a figure) which was not significantly different.	**Vakulin et al. [18]**	2007
Insufficient sleep	Braking reaction time	Healthy young drivers	Sleep amount	Sleep deprivation (2 hours) (n=10, crossover)	No sleep deprivation (8.5 hours) (n=10, crossover)	Sleep restriction with fatigue statistically significantly increased braking reaction time by a mean of 650 ms (compared to rested condition in driving simulator). At 75 miles per hour, this translates to 23 meters increase in braking distance.	**Philip et al.[98]**	2003
Insufficient sleep	Speed: Deviation	Healthy adults	Duration of time awake	26 hours of supervised wakefulness (n=15)		Speed deviation was kph over or under posted limit Mean value at duration of wakefulness, estimated from figure: 4-6 hours: 5 8-10 hours: 6 18-20 hours: 9 24-26 hours:8 There was statistically significantly greater speed deviation with longer wakefulness.	**Baulk et al. [16]**	2008
Insufficient sleep	Speed: Deviation	Healthy young men	Duration of time awake	Performance during 10-minute simulated drive at wakefulness from 2 hours to 22 hours (n=14)		Mean deviation from speed limit in km/h varied at each of the collected time points (from 2 hours prior wake to 22) from a low of about 0.5 at 4 hours to a high of about 0.75 at 19.5 hours, but the differences were not statistically significant. The data were estimated from a figure.	**Matthews et al. [19]**	2012
Insufficient sleep	Speed, mean	Drivers, recruited from college campus	Sleep amount	Sleep deprivation (n=24, crossover)	After normal night's sleep (n=24, crossover)	20 minute simulated drives at 8 am, 11 am, 2 pm, 5 pm, and 8 pm Sleep deprivation was associated with reduced ability to maintain target speed Drivers were closest to target speed at 5 and 8 p.m. sessions No significant changes in mean speed within sessions were recorded.	**Lenne et al.[24]**	1998
Insufficient sleep	Speed, standard deviation (variability)	Drivers, recruited from college campus	Sleep amount	Sleep deprivation (n=24, crossover)	After normal night's sleep (n=24, crossover)	20 minute simulated drives at 8 am, 11 am, 2 pm, 5 pm, and 8 pm Sleep deprivation was associated with significantly greater speed variation overall and by time of day, with worst performance at 8 a.m. and 2 pm. However, there were not significant variations within sessions.	**Lenne et al.[24]**	1998
Insufficient	Speed:	Healthy	Duration of	Performance during 10-minute simulated drive at		Speed variability is the standard deviation around the speed deviation, in km/h. It was fairly constant around zero until 17 hours when the mean	**Matthews et**	2012

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
sleep	Variability	young men	time awake	wakefulness from 2 hours to 22 hours (n=14)		was highest at about 0.4; however, the differences were not statistically significant. The data were estimated from a figure.	**al. [19]**	
Insufficient sleep Circadian - overnight Task-related	Speed: Variability	Young healthy college students	Duration of time awake	Performance during 30 minute simulated drive over time after a normal day, midnight, 2:30 am, 5 am, and 7:30 a.m. (n=29)		With increased time awake, speed variability increased statistically significantly. Also, it was statistically significantly worse at 7:30 than at the previous assessments. Deterioration during the drive was statistically significantly faster at the later assessment times.	**Arnedt et al. [20].**	2005
Insufficient sleep	Speed: Violation	Healthy young men	Duration of time awake	Performance during 10-minute simulated drive at wakefulness from 2 hours to 22 hours (n=14)		Number of speed violations was the number of minutes drivers went more than 5 km/h over the speed limit during the 10-minute driving simulation. From 4 hours the number increased, from zero at 4 hours to 0.4 at the study end. These differences were not statistically significant. The data were estimated from a figure.	**Matthews et al. [19]**	2012
Insufficient sleep	Steering: Deviation	Healthy young men	Amount of overnight sleep	4 hours in bed (n=21) (crossover)	8.5 hours in bed (n=21) (crossover)	Driving task was 70 minutes and started at 2 pm After the first 10 minutes the mean steering deviation in cm increased from 32.5 to 37 in the control group and from about 30 to 35 in the sleep-restricted group at final follow up (as estimated from figure). The difference between groups was not statistically significantly different at any time point and was not statistically significantly different over time.	**Vakulin et al. [18]**	2007
Insufficient sleep Task-related Circadian: Mid-afternoon task	Steering: Wheel movement, amplitude	Healthy men	Change over 90 minute drive time, and group comparison	No sleep deprivation (n=20, crossover)	Overnight sleep deprivation (4 hours sleep 3 a.m. – 7 am) (n=20, crossover)	Testing between 2 and 4 pm Sleep deprivation had no significant effect on mean amplitude of small steering wheel movements. Values estimated from figure ranged from a low of about 1.9 for both groups in the 30th minute period to a high of a little over 2.2 for periods of 70th, 80th, and 90th minutes.	**Otmani et al. [23]**	2005
Insufficient sleep Task-related Circadian: Mid-afternoon	Steering: Wheel movement, frequency	Healthy men	Change over 90 minute drive time, and group comparison	No sleep deprivation (n=20, crossover)	Overnight sleep deprivation (4 hours sleep 3 a.m. – 7 am) (n=20, crossover)	Testing between 2 and 4 pm Frequency per minute of small steering wheel movements was not statistically significantly associated with sleep deprivation. The mean frequency was highest during the first 10 minutes (30 sleep deprived, 30 rested) but was thereafter consistently between about 27.5 and 28.5, as estimated from a figure.	**Otmani et al. [23]**	2005

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
task								
Circadian: Mid-afternoon task	Lane deviation variability	Healthy young adults	Time of day	Performance during simulated drive at four time points during day (n=31)		Percentile deviation of center of car from center of lane (edge of left lane =100%, edge of right lane = 0%, so ideal is 25%). Mean (standard deviation) %: 10 am: 29.8 (5.4) Noon: 28.3 (3.9) 2 pm: 28.9 (4.3) 4 pm: 28.9 (4.1)	**Moller et al. [96]**	2006
Circadian: Mid-afternoon task	Lane deviation	Healthy young adults	Time of day	Performance during simulated drive at four time points during day (n=31)		Number of incidents in which the center of the vehicle either crossed over the lane edge or blocked a passing vehicle. Mean (standard deviation): 10 am: 1.2 (1.7) Noon: 1.3 (1.7) 2 pm:1.6 (2.0) 4 pm: 1.3 (1.3) No comparisons were statistically significantly different.	**Moller et al. [96]**	2006
Circadian: Mid-afternoon task	Road position	Healthy young adults	Time of day	Performance during simulated drive at four time points during day (n=31)		Standard deviation of road position, percentile. Mean (standard deviation): 10 am: 8.3 (2.8) Noon: 8.3 (2.8) 2 pm: 8.5 (2.5) 4 pm: 8.3 (2.6) No differences were statistically significant	**Moller et al. [96]**	2006
Circadian: Mid-afternoon task	Reaction time	Healthy young adults	Time of day	Performance during simulated drive at four time points during day (n=31)		Reaction time to corrective steering in response to wind gust Mean (standard deviation): 10 am: 0.96 (0.45) Noon: 1.05 (0.42) 2 pm: 1.09 (0.39) 4 pm: 1.04 (0.39) Differences were statistically significant between 10 a.m. and each of the other assessment times	**Moller et al. [96]**	2006
Circadian: Mid-	Speed:	Healthy	Time of day	Performance during simulated drive at four time		Mean sum of differences of vehicle speed from speed limit.	**Moller et al.**	2006

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
afternoon task	Deviation	young adults		points during day (n=31)		Mean (standard deviation): 10 am: -1.0 (4.6) Noon: 1.2 (7.9) 2 pm: 1.1 (4.2) 4 pm: 1.6 (4.4) Difference is statistically significant between 10 a.m. and 2 p.m. and 10 a.m. and 4 pm	**[96]**	
Circadian: Overnight task	Lane deviation	Healthy young men	Time of day	3-5 am 1-5 am 9pm-5 a.m. drives (n=14) (crossover)	9-10 p.m. drive (n=14) (crossover)	The longer driving sessions were associated with statistically significantly greater incidence of inappropriate line crossings than in the short driving session and the reference session. Inappropriate line crossings occurred at statistically significantly greater incidence for all three overnight driving groups than the reference drive, and the longer the drive the greater the difference in incidence. The cumulative number of inappropriate line crossings in the last hour of drive (or reference session) were: 9-10 pm: 7 3-5 am: 42 1-5 am: 108 9pm-5am: 170	**Sagaspe et al. [94]**	2008
Circadian: Overnight/ After night shift Insufficient sleep	Crash, simulated	Night shift workers	After night shift vs. waking up at conventional time (tested at 8 am)	After night shift (n=10, crossover)	Same time, just woke up (n=10, crossover)	There were two simulated crashes in the rested condition and 18 in the post-shift condition, which when corrected for four early terminations due to excessive drowsiness in the night-shift condition by assessing time to first crash or to premature termination was 83 (11.5) minutes in the shift condition and 116.5 (3) in the rested group, a statistically significant difference. A post-hoc analysis by Ingre et al. 2006[100] found that once self-reported sleepiness was factored in, the time and condition were no longer statistically significant predictors of events.	**Akerstadt et al.[97]**	2005
Circadian: Overnight/ After night shift Insufficient	Incidents	Night shift workers	After night shift vs. waking up at convention al time (tested at 8	After night shift (n=10, crossover)	Same time, just woke up (n=10, crossover)	Over the 2 hour drive, rested drivers had a mean of 2.4 (1.1) incidents, and when coming off the night shift they had a mean of 7.6 (2.1). This difference is statistically significant. Four of the 10 drivers could not complete the task after night shift due to excessive drowsiness and contributed only partial data. A post-hoc analysis by Ingre et al. 2006[100] found that once self-reported sleepiness was factored in, the time and condition were no longer statistically significant predictors of events.	**Akerstadt[97]**	2005

Causative Factor(s)	Outcome Assessed	Population	Comparison Made	Intervention / Exposure (n=)	Control(s)/ Other Exposure (n=)	Findings	Reference	Year
sleep			am)					
Task-related	Crash (simulated)	Drivers Healthy young men	Time on task	Time on task during 90 minute drive (n=30)		90 minute highway simulated driving task, started at 2: 30 pm Crash did not vary significantly by drive time	**Ting et al.[95]**	2008
Task-related	Following distance	Drivers Healthy young men	Time on task	Time on task during 90 minute drive (n=30)		90 minute highway simulated driving task, started at 2: 30 pm Mean following distance (headway) varied significantly with time, especially during the last 10-minutes compared to the first 10-minutes.	**Ting et al.[95]**	2008
Task-related	Lane cross	Drivers Healthy young men	Time on task	Time on task during 90 minute drive (n=30)		90 minute highway simulated driving task, started at 2: 30 pm Frequency of edge-line crossings varied significantly with time, especially during the last 10-minutes compared to the first 10-minutes.	**Ting et al.[95]**	2008
Task-related	Lateral position, variation	Drivers Healthy young men	Time on task	Time on task during 90 minute drive (n=30)		90 minute highway simulated driving task, started at 2: 30 pm Standard deviation of lateral position varied significantly with time, especially during the last 10-minutes compared to the first 10-minutes.	**Ting et al.[95]**	2008
Task-related	Speed, variation	Drivers Healthy young men	Time on task	Time on task during 90 minute drive (n=30)		90 minute highway simulated driving task, started at 2: 30 pm The standard deviation of drive time varied significantly with time, especially during the last 10-minutes compared to the first 10-minutes.	**Ting et al.[95]**	2008
Task-related	Steering wheel movement	Drivers Healthy young men	Time on task	Time on task during 90 minute drive (n=30)		90 minute highway simulated driving task, started at 2: 30 pm Steering wheel movement did not vary significantly by drive time	**Ting et al.[95]**	2008
Task-related	Steering wheel movement, variation	Drivers University students	Driving environment	Monotonous drive (n=56, crossover)	Varied drive (n=56, crossover)	Tested at 1:20 p.m. and 2:25 start time for 40 minute drive Steering wheel movement and variability of movement increased over time during each drive. The authors attribute this to task fatigue. The difference in steering wheel movement between simulated environments was not statistically significant.	**Thiffault and Bergeron[99]**	2003
Task-related	Multiple (lateral position, mean and SD; steering error, mean and SD)	Drivers	Time of day, environment type	Monotonous drive, morning and afternoon (n=17, crossover)	Varied drive, morning and afternoon (n=17, crossover)	Drive 40 minutes between 9-11 a.m. and between 1-3 p.m. in monotonous and more stimulating driving environment (4 drives per driver). Driving performance worsened during the task and was poorer in the afternoon drive. The environment type was also significant, with the monotonous conditions associated with poorer driving performance. Individual driver data reported in publication by outcome.	**Rossi et al.[93]**	2011

Section Summary

Table 19 summarizes the key findings of our assessment on the association between non-pathological fatigue and driving ability. In this table, down arrows represent impairment.

No conclusions are possible about the impact of non-pathological fatigue on driving ability in motorcoach drivers because no studies assessed this population. We, therefore, assessed information from other types of professional drivers and found that minimally acceptable evidence suggests critical event rates increase over 11-hour driving shifts. In general, the studies suggest fatigue impairs driving ability, but no other specific conclusions about professional drivers are possible because each of most of the studies report different outcomes. To gather more data, we also reviewed evidence from nonprofessional drivers. Moderate-strength evidence suggests insufficient sleep leads to greater incidence of simulated crash, and strong evidence associates it with decreased ability to drive within lane. Other measures of driving ability in nonprofessional drivers were addressed by fewer studies with less consistent findings. This evidence was therefore insufficient to support evidence-based conclusions.

Table 19. Summary Findings on the Effects of Non-pathological Fatigue on Driving Ability

Reference	Year	Fatigue Type(s) Addressed	All violations	Crash / Critical Events	Lane deviation /Tracking	Reaction time	Running off road	Speed-related	Steering-related	Tailgating /. Following distance
Professional Drivers										
NTRCI / Fine et al. [87]	2012	Naturalistic	↓	↔				↔		↓
Barr et al.[34]	2011	Naturalistic	↔					↔		
Naturalistic Truck Driving Study[14, 15]	2011	Task-related		↓						
Kee et al. [88]	2010	Task-related					↓	↓		
Drowsy Driver Warning System Study[12, 13]	2009	Circadian Task-related		↓						
Mortazavi et al.[89]	2009			↓	↓			↔	↓	
Howard et al. [90]	2007	Insufficient sleep Circadian			↔			↔		
Hanowski et al.[91]	2003	Naturalistic								
Commercial Motor Vehicle Driver Fatigue and Alertness Study[64]	1996	Task-related			↔					
Fuller[92]	1983	Task-related Circadian		↓						↔
Non-professional Drivers										
Matthews et al. [19]	2012	Insufficient sleep			↓			↔		
Rossi et al.[93]	2011	Task-related			↓				↓	
Baulk et al. [16]	2008	Insufficient sleep		↔	↓			↓		

Reference	Year	Fatigue Type(s) Addressed	All violations	Crash / Critical Events	Lane deviation /Tracking	Reaction time	Running off road	Speed-related	Steering-related	Tailgating /. Following distance
Sagaspe et al. [94]	2008	Circadian			↓					
Ting et al. [95]	2008	Task-related		↔	↓			↓	↔	↓
Park et al. [22]	2007	Insufficient sleep			↓					
Vakulin et al. [18]	2007	Insufficient sleep		↓		↔			↔	
Moller at el. [96]	2006	Circadian			↓	↓		↓		
Akerstadt et al.[97]	2005	Circadian Insufficient sleep		↓						
Arnedt et al. [20]	2005	Insufficient sleep Circadian Task-related			↓		↓	↓		
Otmani et al. [23]	2005	Insufficient sleep Circadian Task-related			↓				↔	
Philip et al. [21]	2005	Insufficient sleep			↓					
Philip et al.[98]	2003	Insufficient sleep								
Thiffault and Bergeron[99]	2003	Task-related							↓	
Peters et al. [17]	1999	Insufficient sleep Circadian		↔						
Lenne et al.[24]	1998	Insufficient sleep			↓			↔		

↓Indicates the variable is a detriment with acute fatigue. Note: If a study reported more than one related outcomes and at least one showed statistically significant detriment, a down arrow was assigned. If fatigue showed a benefit, an up arrow would have been assigned.
↔ Indicates there is no detriment of variable with acute fatigue.

Key Question 2: How much rest does a fatigued professional driver need to resume driving unimpaired?

The original purpose of Key Question 2 was to determine the minimum average duration of rest that motorcoach drivers who become fatigued while driving need before they return to normal non-fatigued functioning and can resume driving a motorcoach unimpaired. Because no studies directly address that original purpose, we expanded the scope of evidence included to indirectly address it with related evidence, as described in the following paragraph. While these scope expansions mean that not all included evidence directly addresses the key question, it enables the provision of the most relevant information available.

We define rest as time not working, which may or may not include sleep. Rest can take place during a shift break, before a shift (eg, overnight sleep), or between shifts (eg, reset). Because limited information was identified on how long the rest break should be, we also include information on whether rest or nap breaks of any duration are helpful. Breaks can be planned or taken in response to fatigue. As no studies on motorcoach drivers were identified, we assessed studies on commercial truck and bus drivers, limiting the scope to these driver groups for the sake of applicability to motorcoach drivers. General population studies, which often enroll university student volunteers, would not have provided comparable outcomes on task-related fatigue, sleep durations, circadian factors, and circadian disruption. We also expanded our outcomes to include fatigue (ie, tiredness) and sleepiness (ie, drowsiness). This question is designed to gather information about average group performance because that is the level of outcome data studies generally report; however, differences among individuals in areas including sleep debt and personal need for sleep vary considerably and impact the duration of rest needed.

The following text summarizes the systematic literature search findings and study selection process, provides an overview of the included literature, and reports study findings.

Identification of Evidence Base

Database search strategies are provided in Appendix A Retrieval Criteria are provided in Appendix B, and Inclusion Criteria are provided in Appendix C. Included publications are English language original research studies addressing the amount of rest needed for non-pathologically fatigued professional drivers to reach pre-fatigue functioning, fatigue, or sleepiness levels. Searches identified 5,357 references, of which 181 were potentially relevant based upon title and abstract review. Of those, 32 were unavailable in full length and could not be retrieved. Of those reviewed in full-length text, 135 were excluded for the following reasons: does not address the Key Question, k=68; not a full study report, k=33; not a population of interest, k=27; fewer than 10 people enrolled total, or fewer than 5 per group, k=6; duplicate record k=2; review article, k=1. Excluded citations and reasons for their exclusion are provided in Appendix D. Ultimately, twelve publications describing ten studies met our inclusion criteria. The study selection process is illustrated in Figure 6, below. Following that, the included studies are listed in Table 20.

Figure 6. Development of Evidence Base for Key Question 2

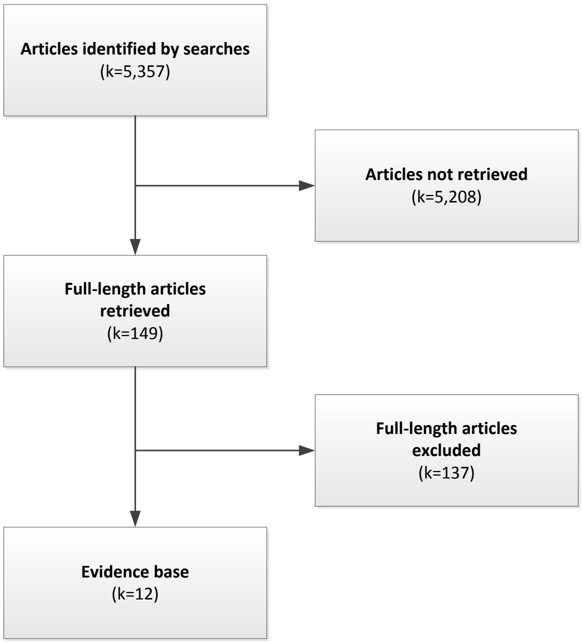


Table 20 identifies the studies utilized in this key question, where they were conducted, and the scale of them (ie, national, local, etc.)

Table 20. Evidence Base for Key Question 2

Reference	Year	Study Location	Region/Scale
Barr et al.[34]	2011	United States	NR Local/short haul
Jovanis et al.[101]	2011	United States	NR
Naturalistic Truck Driving Study: Blanco et al.[26]	2011	United States	NR
Drowsy Driver Warning System Study: Hanowski et al.[31]	2007	United States	NR
Dorrian and Dawson[29]	2005	United States	Nationwide records
Perez Chada[25]	2005	Argentina	NR, surveyed near Buenos Aires
Belenky et al.[32] **Balkin et al. 2000[33]**	2003 2000	United States	Laboratory (sleep center)
Wylie 1998[28] **Wylie 1996***[102]	1998 1996	United States Canada	St. Louis, Missouri to Kansas City Missouri-Kansas Toronto to Montreal
Hertz [30]	1988	United States	Nationwide
Boiven et al.[27]	NR	Canada	Surveyed in Calgary, Toronto, Montreal, most driving long-haul

NR – Not reported
*Wylie 1996 provided useful information on the study that Wylie 1998 conducted a post-hoc analysis of, but did not report findings in a way that addressed the key question

Data Abstraction and Evidence Base Description

The included studies assess shift breaks, sleep before shift (presumably generally overnight sleep), or between-workweek breaks (reset periods, analogous to a weekend). Most studies specifically assess the amount of sleep or time in bed, while others assess time off work. Only one study identified that it included bus drivers; however, it did not specifically note which participants were coach drivers, or report what proportion of the total study sample was bus drivers (the rest were truck drivers).[32]

As shown in Table 21, most of the included studies assess driving function directly, but they use different methods. Some studies rely on questionnaires or records of actual driving. Some of the real-world driving studies are naturalistic, meaning analysts viewed video of drivers and recorded signs of fatigue or sleepiness and recorded signs of driving function impairment, such as traffic incidents. Others measured function using driving simulators. One included study measures psychomotor vigilance among drivers with a reaction-time test that is commonly used as a proxy for driving function.

The key characteristics of each study are summarized in Table 21. Detail of the studies' populations is shown in Table 22.

Table 21. Study Design Characteristics for Key Question 2

Reference	Year	Study Design	Participants N =	Data Collection Method	Sample Type	Comparison made (of interest to KQ 2)	Year(s) Data Collected	Break Type		
								During Shift	Over-night	Restart
Barr et al.[34]	2011	Single-arm time series	41	Video / observational	Convenience	Drowsy and baseline events	NR		✓	
Drowsy Driver Warning System Study [31]	2011	Single-arm time series	62	Video / actigraphy / observational	Convenience	Sleep preceding safety critical events and overall sleep duration	NR		✓	
Jovanis et al.[101]	2011	Case-control with logistic regression	1,564	Records	All crashes included, controls selected randomly	34-hour recovery period vs. none, comparison group and logistic regression	2004-2005 and 2010			✓
Naturalistic Truck Driving Study[26]	2011	Pre-post (for analysis of interest)	97	Video / observational	Convenience	Safety critical events with different durations of driving hours, work hours, and breaks	2005-2007	✓		
Perez Chada[25]	2005	Cross-sectional study	738	Survey	Convenience	Did and did not have nap, critical safety event (regression analysis)	2001	✓		
Dorrian and Dawson[29]	2005	Case-control	107	Records Questionnaire	NR	Amount of sleep in 24 hours preceding crashes in which fatigue did and did not play a role, comparison group	NR		✓	
Belenky et al. 2003[32] **Balkin et al. 2000[33]**	2003 2000	Non-randomized controlled trial	66	Experimental	Convenience	Duration of nightly recovery (time in bed), control groups	NR		✓	
Hertz[30]	1988	Case-control	418 cases, 15,6t92 controls (records)	Record review	All records	Tractor-trailer crashes with fatality (cases) or property damage only (controls)	1984		✓	
Wylie 1998[28] **Wylie 1996[102]**	1998 1996	Pre-post	25 (relevant)	Wylie 1998 used records from original 1996 study	Convenience	On-shift nap duration, pre-post sleepiness levels and comparison by nap duration	1993	✓		
Boiven et al.[27]	NR	Cross-sectional,	303	Survey	Convenience	Duration of napping on shift and	2003	✓		

Reference	Year	Study Design	Participants N =	Data Collection Method	Sample Type	Comparison made (of interest to KQ 2)	Year(s) Data Collected	Break Type		
								During Shift	Over-night	Restart
		nested cohort comparison				sleeping after shift, cohort divided				

NR – Not reported

Table 22. Participant Characteristics for Key Question 2

Reference	Year	Distance	Inclusion Criteria	Exclusion Criteria	Sex	Race/Ethnicity	Age (Years) Mean (SD)	Years of Driving Experience
Barr et al.[34]	2011	Local and short–haul	Truck drivers NR	NR	NR	NR	NR	NR
Jovanis et al.[101]	2011	Long–haul	Truck drivers Cases: Drivers who crashed with fatality, injury that had to be treated off-site, or towing Controls: No crash Sub-analysis of drivers with and without 34-hour recovery before starting new drive Records from participating companies	NR	NR	NR	NR	NR
Naturalistic Truck Driving Study[26]	2011	Long-haul 77% Line-haul 22%	Truck drivers Professional volunteer drivers from participating companies	NR	95% male	NR	44 (Range 21-73)	Mean: 9.13 (range 4 weeks – 54 years)
Drowsy Driver Warning System Study [31]	2007	NR	Truck drivers Professional volunteer drivers from participating companies No glasses Drive primarily at night	NR	99% male	NR	39.1 (Range 24-58)	NR
Dorrian and Dawson[29]	2005	NR	Truck drivers Drivers who crashed and had on-scene truck crashes investigation, with records identified by NTSB	NR	100% male	NR	Range 23-66	NR

Reference	Year	Distance	Inclusion Criteria	Exclusion Criteria	Sex	Race/Ethnicity	Age (Years) Mean (SD)	Years of Driving Experience
Perez Chada[25]	2005	>800 km per day Long-haul	Licensed, long-haul commercial truck drivers	NR	99% male	NR	38.1 (11.1)	NR
Belenky et al. 2003[32] **Balkin et al. 2000[33]**	2003 2000	Laboratory simulator, short drives	Truck and bus drivers Valid CMV driver's license Good general health determined by record assessment and exam	Nicotine Caffeine >400 mg/day Medications other than birth control	76% male	Caucasian: 49 African-American: 15 Biracial (of the above): 1 Hispanic: 1	Women: 34 (Range 24-55) Men: 37 (Range 24-62)	Mean: NR "Differed widely"
Wylie 1998[28] **Wylie 1996**[102]	1998 1996	US Route, 500 miles round-trip Canada route, 662 miles round-trip	Truck drivers 1998 analysis: Naps with video recording 1996: At least 1 year experience driving class 8 tractors; free from controlled substances and alcohol; no documented medical history of sleep disorder	NR	100% male	NR	Range 25-65	At least one year driving class 8 tractors
Hertz[30]	1984	Any	Truck drivers Record in Bureau of Motor Carrier Safety crash database, 1984	NR	NR	NR	39 (Range 17- 72)	Mean length with current company: ~ 4.5 years
Boiven et al.[27]	NR	Long-haul: 79% Short-haul: 21%	Truck drivers CMV drivers at selected truck stops during weekdays between 7:45 a.m. and 10 p.m.	NR	98% Male	NR	<30: 9% 30-39: 22% 40-49: 34% 50-59: 27% >60: 8%	Mean: 19 (1-50, SD 12)

CMV – Commercial motor vehicle; NR – Not reported; NTSB – National Transportation Safety Board; SD – Standard deviation

Risk of Bias Assessment

For this key question the two most important potential risks of bias emanate from sampling bias and selection/group allocation bias. Sampling bias is the potential influence of how the population was selected on the outcome. If the sample selected was not representative of the actual population it is intended to represent, the results of the study may not be either. Convenience sampling (as opposed to consecutive or random sampling) puts studies at particular risk for sampling bias, especially observational studies. Selection or group allocation bias is the risk there are important differences between comparison groups aside from the exposure of interest (ie, duration of rest) that influences the outcome. Observational studies are generally at higher risk of this type of bias as well, because they have not been randomly or otherwise objectively assigned to groups. For instance, there may be important reasons why drivers choose to take certain break patterns or sleep for a certain duration at night or drive long vs. short-haul trips. Most studies addressing Key Question 2 are observational.

Table 23 summarizes risk of bias findings for this key question. An itemized risk of bias assessment for each included study is summarized in Appendix E. A risk of bias rating was determined for each included study based upon appraisal of these assessments, with particular attention placed on items assessing the risk for sampling bias and items that address selection/group allocation bias. Observational studies and studies at risk of one of these biases were never rated as "low risk of bias." Observational studies that do not address sampling bias and other studies at risk of both of these biases were rated as "high risk of bias." Accordingly, the risk of bias rating for each included study was found to be "moderate" or "high."

Table 23. Risk of Bias Assessment for Key Question 2

Reference	Year	Quality Scale Used	Bias Risk
Barr et al.[34]	2011	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Jovanis et al.[101]	2011	Newcastle Ottawa Assessment Scale for Case-Control Studies (Revised)	Moderate
Naturalistic Truck Driving Study[26]	2011	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Drowsy Driver Warning System Study [31]	2007	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Dorrian and Dawson[29]	2005	Newcastle Ottawa Assessment Scale for Case-Control Studies (Revised)	Moderate
Perez Chada[25]	2005	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Belenky et al.[32] **Balkin et al. 2000[33]**	2003 2000	JBI Controlled Trial Instrument	Moderate
Wylie 1998[28] **Wylie 1996*[102]**	1998 1996	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High
Hertz[30]	1988	Newcastle Ottawa Assessment Scale for Case-Control Studies (Revised)	Moderate
Boivin et al.[27]	NR	JBI Descriptive / Case-series Risk of Bias Assessment Tool	High

Generalizability of Evidence Base to Motorcoach Drivers

No included studies addressed motorcoach drivers. One study addressed both bus and truck drivers, but it did not report how many bus drivers there were or provide details of their responsibilities. The remaining studies examined commercial truck drivers, mostly long-haul. Truck drivers may have relatively similar stressors that affect sleep debt and need for rest, such as insufficient sleep, driving overnight, and similar driving tasks and related fatigue. Data from the evidence base used to address Key Question 3 (see below) suggest that truck drivers typically drive more miles per week than motorcoach drivers, so it is possible they are more acclimated to coping with task-related fatigue; on the other hand, they may have more underlying sleep debt. The flexibility for truck drivers' break location and duration compared to motorcoach drivers probably varies considerably, depending on schedule and route. Key Question 3's findings reveal more females likely drive bus or motorcoach than truck; in this key question far fewer drivers are female. Furthermore, Key Question 3 reports the median age of motormotorcoach/bus drivers to be the late forties. In this question, study participants were slightly younger. The potential impact of these demographic differences on need for rest is unclear.

Findings

The findings, divided by rest type (during shift, before shift, restart between shifts), are reported in terms of function, fatigue, and sleepiness, with attention to duration of rest assessed (where reported) and the population studied. These data are provided in Table 24.

Motorcoach Drivers

No included studies assessed only motorcoach drivers or presented data in a manner that allowed us to specifically address this driver group.

Other Commercial Motor Vehicle Drivers

Rest during Shift

Among truck drivers, two studies found a 30-minute rest break reduced the incidence of safety critical events. One study did not find an association between nap duration and fatigue, and another did not find an association between nap duration and sleepiness. This weak evidence suggests that rest or nap breaks may improve function but not necessarily feelings of sleepiness or fatigue. *(Strength of Evidence: Minimally Acceptable)*

Function

Perez-Chada, 2005[25], and the Naturalistic Truck Driving Study, 2011[26], assessed the impact of rest during shift on driving function. Perez-Chada compared the incidence of safety critical events in long-haul truck drivers who did and did not leave the road to take a 30- to 40-minute rest break in response to sleepiness, and found that those who napped had a significantly lower incidence of crash or near crash. In the Naturalistic Truck Driving Study, safety critical event incidence was compared in truck drivers before and after a 30-minute rest break, during which drivers did not work and did not necessarily sleep. The study found the safety critical event incidence was 28 percent lower after the break.

Fatigue

Boivin et al.[27], which compared self-reported fatigue among truck drivers based upon their reported duration and frequency of rest, did not find an association between fatigue and time napping on or after shifts.

Sleepiness

Wylie et al., 1998[28] compared objective measures of sleepiness (eg, droopy eyelids, repeated blinks, as recorded on video and reviewed by investigators) and self-reported sleepiness in truck drivers before and after they took naps. The authors reported wide variation within and between drivers in signs and symptoms of sleepiness before and after naps. Their analysis could not link duration of nap sleep time with post-rest alertness; the authors postulated this might be due to the wide variation among individuals.

Sleep before Shift

Four studies collectively suggest a minimum of 4 to 6.7 hours sleep is needed in the 24 hours before driving and that a minimum total of at least 8 to 12 hours is needed in the 48 hours before driving to reduce the incidence of driving-related functional impairment. One study suggests that consecutive sleep is more beneficial than divided sleep. Two studies suggest shorter durations of sleep are associated with greater sleepiness, especially among drivers sleeping about 4 to 4.75 hours or less overnight. *(Strength of Evidence: Minimally Acceptable)*

Function

Four studies, listed below, addressed the association between duration of sleep before shift and crash, safety critical event, or driving-related psychomotor vigilance.

Two of those studies assessed crash. Dorrian and Dawson,[29], analyzed the amount of sleep before a crash among truck drivers with fatigue-related crash and those with crash due to other causes (eg, weather, speeding), finding that crash was less likely to be due to fatigue if the driver slept more than 6.5 hours in the preceding 24 hours *and* at least 8 hours total in the preceding 48 hours. The authors emphasized that these factors are most predictive of fatigue-related crash when considered together. Hertz et al.[30], compared fatal crash incidence in tractor-trailer drivers, who slept in two four-hour shifts in the sleeper berth, to those who slept eight hours continuously, finding the adjusted odds ratio of fatal crash was about three times higher in the broken rest group.

Hanowski et al.[31] assessed safety critical events, including crash and near-crash. The study reported the mean duration of sleep the night before a critical incident during the 10th or 11th hour of driving was 5.28 (SD 2.03) hours. The overall study period mean was 6.63 (SD 1.47) hours. The findings were similar whether or not drivers were at fault.

The remaining study assessed driving-related psychomotor vigilance. Belenky et al. [32], and Balkin et al. [33], conducted an experimental laboratory study in which truck and bus drivers were assigned to three, five, seven, or nine hours in bed overnight for a week, and the duration of sleep was physiologically monitored. Psychomotor vigilance task performance declined for all groups except the nine-hour group. Impairment was seen starting on day two for the three-hour group, and starting on day three for the five-hour group. The sleep-deprived groups then were assigned to a three-day recovery period with eight-hour nights, and psychomotor task recovery was observed for the three-hour group on the first day, but not at all for the five-hour group. The study authors concluded that at least four hours of sleep per night is required to maintain daytime alertness and performance.

Fatigue

No studies addressed this outcome.

Sleepiness

Two studies assessed pre-shift rest or sleep and sleepiness. Belenky et al. [32], and Balkin et al., [33], described above, also reported objective sleepiness outcomes (ie, time to fall asleep at night) and self-reported sleepiness. They found the group assigned to three hours of rest in bed per night reported statistically significantly greater sleepiness after the first night, but the groups with five, seven, or nine hours in bed per night did not. They reported the time to fall asleep significantly shortened for the three- and five-hour groups, and that recovery on this outcome was not observed after the participants were reassigned to the three-day recovery period with eight hours of bedtime per night. No changes were observed in the seven- and nine-hour rest groups throughout the study. As noted above, the authors concluded at least four hours of sleep per night is necessary to maintain alertness and performance.

Barr et al.,[34], found that drivers judged drowsy by analysts watching videos of them, slept significantly less prior to driving than drivers who did not appear drowsy; however, the mean difference was small (285 minutes vs. 298 minutes, or 14 minutes mean difference). The authors did not find a relationship between time in bed and drowsiness, or the duration of sleep two or three days prior and drowsiness.

Restart

No conclusion is possible regarding the duration of restart needed to improve or maintain function, fatigue, or sleepiness outcomes, because only one study addresses this type of rest.

Function

Jovanis et al.,[101], assessed the relationship between a 34-hour recovery period and crash in truck drivers. It reported that for those with a full load, crash incidence was statistically significantly greater when driving resumed at night compared to drivers who did not have a restart break. For drivers with a less-than-full load, crash incidence increased when driving resumed during the day compared to drivers who did not have a reset break.

Fatigue

No studies addressed this outcome.

Sleepiness

No studies addressed this outcome.

Table 24. Comparisons and Findings for Key Question 2

Outcome Assessed	Scale Used	Population	Comparison Made	Intervention/ Exposure (N=)	Control(s)/ Other Exposure (N=)	Findings	Reference	Year
Rest during shift								
Function	Safety critical event incidence	Long-haul truck drivers	Event in drivers who did and did not leave road for a 30- to 40-minute break	Exposure Left road and took 30- to 40-minute nap (458)	Exposure No nap (280)	Drivers who reported they left the road to nap for 30 to 40 minutes to fight sleepiness also reported a significantly lower incidence of crash or near crash (unadjusted odds ratio 0.67 [95% CI: 0.49 to 0.91]).	Perez Chada[25]	2005
Function	Safety critical event incidence	Truck drivers	Safety event rate before and 1-hour after nap	Exposure Rate before and after break lasting at least 30 minutes (97)		Rate before nap: 0.150 Rate 1 hour after event: 0.108 Overall: a Ratio of 1.289 and a magnitude reduction of 28 percent events. Drivers rested and did not work, but did not necessarily sleep.	Naturalistic Truck Driving Study[26]	2011
Fatigue	Subjective: Likert scale 1-7 (higher scores greater fatigue)	Truck drivers	Different durations and frequencies of sleep	Exposure Reported duration and frequency of sleep, continuous measure (303)		No correlation was observed between fatigue levels and the time reported spent napping on shift or sleeping after shifts.	Boiven et al.[27]	NR
Sleepiness	Objective: Reported drowsy Droopy eyelids Repeated blinks (video recording)	Truck drivers	Sleepiness before and after nap	Exposure Nap Baseline Number of 6-minute periods judged drowsy before nap (25)	Comparison Number of 6-minute periods judged drowsy after nap (25)	49 naps in 47 trips of 25 drivers analyzed Mean nap duration: 34 minutes 24 instances driver not judged drowsy before nap 25 drivers were drowsy and did nap 12 drivers judged less drowsy after nap 13 drivers judged more drowsy after nap Authors note, “There were large within and between-driver differences in the amount, duration, and timing of drowsiness before and after naps.” Also, “The relative infrequency of naps and the large within- and between-driver differences in drowsiness obscured a precise formula or model for combining nap time with principal sleep time to predict subsequent alertness. While naps could be expected to reduce sleep debt and therefore drowsiness,	Wylie[28]	1998

Outcome Assessed	Scale Used	Population	Comparison Made	Intervention/ Exposure (N=)	Control(s)/ Other Exposure (N=)	Findings	Reference	Year
						this was not confirmed empirically in this data analysis." The findings suggested "naps were associated with increased drowsiness, which on average was seen as a precursor to naps, and also was seen for two hours after naps."		
Sleep Before Shift								
Function	Crash	Truck drivers	Reason for crash (fatigue, other)	Exposure Crash associated with fatigue (62)	Exposure Crash associated with other factors than fatigue (45)	After examining the amount of sleep before the crash, the authors concluded that having at least 6.5 hours sleep in the 24 hours before the crash and at least 8 hours in the 48 hours reduced the likelihood that crash was due to fatigue. The authors emphasized that these two factors are not as highly predictive if separated.	Dorrian and Dawson[29]	2005
Function	Crash, fatal to tractor-trailer driver	Tractor-trailer truck drivers	Sleep in two shifts or one	2 sleep shifts in sleeper berth	8 consecutive hours of rest	In a 24-hour period, sleeping two 4-hour shifts in a sleeper berth was significantly associated with an increase in fatal crash compared to sleeping 8 hours consecutively; the adjusted odds was about three times as high.	Hertz et al. [30]	1998
Function	Safety critical event during 10th or 11th hour of driving	Truck drivers	With and without incident	Exposure Duration of sleep in cohort members the night before a critical incident was compared to their duration of sleep overall during the study (All: 38; At fault: 29)		All incidents: The mean duration of sleep before an incident was 5.28 (SD 2.03) hours, significantly less than the mean during the overall study period, 6.63 (SD 1.47). Driver at fault: The mean duration of sleep before an incident was 5.25 (SD 2.15) hours, significantly less than the mean during the overall study period, 6.70 (SD 1.65).	Drowsy Driver Warning System Study [31]	2007
Function	Psychomotor vigilance test	Truck and bus drivers	Different durations of time in bed	Intervention 9 hours (13) 7 hours (14) 5 hours (13) 3 hours (13)		Mean response speed statistically significantly decreased across the 7 experimental days in the groups that had only 3, 5, or 7 hours in bed per night. Task performance did not change statistically significantly in the 9-hour group. Performance in the 3-hour group was statistically significantly lower than for the 9-hour group on days 2-7, than the 7-hour group on days 3-7, and than the 5-hour group on day 7. The 3-hour group recovered after the first night their schedule changed to 8 hours in bed. The 5-hour group had more impairment on nights 3-7 compared to baseline, and nights 5-7 were impaired compared to nights 1-2. This group did not recover to baseline levels during or after the 3-day recovery period with 8-hour nights. Task performance did not return to baseline during the 3-day recovery period. The 7-hour group time was slower on recovery days 2 and 3	Belenky et al. 2003[32] Balkin et al. 2000[33]	2003 2000

Outcome Assessed	Scale Used	Population	Comparison Made	Intervention/ Exposure (N=)	Control(s)/ Other Exposure (N=)	Findings	Reference	Year
						compared to baseline and the first experimental day. The authors concluded the minimum requirement of nightly sleep to maintain daytime alertness and performance is about 4 hours per night.		
Sleepiness	Objective: Sleep latency test (time to fall asleep)	Truck and bus drivers	Different durations of time in bed	Intervention 9 hours (13) 7 hours (14) 5 hours (13) 3 hours (13)		At baseline, mean time to fall asleep was not statistically significantly different among groups. During the experimental period this duration shortened for the 3- and 5-hour groups, but was not statistically significantly different for the 7- and 9-hour groups. The 3- and 5-hour groups did not fully recover to baseline levels after the 3-day recovery period with 8 hours of time in bed per night.	Belenky et al. 2003[32] Balkin et al. 2000[33]	2003 2000
Sleepiness	Objective: Drowsiness judged by analyst	Truck drivers, short haul	Duration of time in bed	1,000 baseline and drowsy events		Researchers found no statistically significant relationship between time in bed and drowsiness. Data not reported.	Barr et al.[34]	2011
Sleepiness	Objective: Drowsiness judged by analyst	Truck drivers, short haul	Duration of sleep	1,000 baseline and drowsy events		Researchers found the mean sleep duration prior to a drowsy event was 285 minutes, statistically significantly shorter than for baseline events, 298 minutes. The researchers did not find a statistically significant relationship between sleep duration 2 to 3 nights prior to duty and drowsiness.	Barr et al.[34]	2011
Sleepiness	Subjective: Stanford sleepiness scale (Likert scale)	Truck and bus drivers	Different durations of time in bed	Intervention 9 hours (13) 7 hours (14) 5 hours (13) 3 hours (13)		Sleepiness ratings were not statistically significantly different among the groups at baseline, the first experimental day, or the recovery days. Sleepiness ratings did not statistically significantly change in the 5-, 7-, and 9-hour groups. In the 3-hour group, ratings increased statistically significantly in the experimental week.	Belenky et al. 2003[32] Balkin et al. 2000[33]	2003 2000
Restart								
Function	Crash	Truck drivers	Recovery period (34 hour) of drivers who did and did not crash	Exposure Crash (318 full truckload, 224 less than full load)	Exposure No crash (560 truckload, 462 less than full load)	Analyses showed overall increased crash incidence among the drivers who had a 34-hour recovery period, including over multiday driving shifts. Compared to no 34-hour recovery period before trip baseline, for return to work after 34-hour recovery period: Full load: Crash incidence was elevated when driving	Jovanis et al.[101]	2011

Outcome Assessed	Scale Used	Population	Comparison Made	Intervention/ Exposure (N=)	Control(s)/ Other Exposure (N=)	Findings	Reference	Year
						resumed at night (odds ratio 1.6 [95% CI: 1.1 to 2.4). There was an insignificant trend to increased crash incidence when the driving resumed during the day (odds ratio 1.3 [95% CI: 0.93 to 1.86). Not full load: Crash incidence was elevated when driving resumed during the day (odds ratio 2.5 [95% CI: 1.4 to 4.5]). Incidence trended toward increased when the driving resumed at night (odds ratio 1.6 [95% CI: 0.9 to 2.7).		

NR – Not reported; SD -- Standard deviation

Section Summary

The optimal duration of rest needed for motorcoach drivers or other commercial drivers to recover from non-pathologic fatigue cannot be conclusively determined based upon current available evidence. No studies address motorcoach drivers. Available studies primarily assess commercial truck drivers and had various research objectives and methods, complicating integration of their findings. No clear evidence-based conclusions are therefore possible; the following text summarizes what current evidence suggests.

Minimally acceptable evidence suggests resting or napping for 30 minutes during a work break may reduce the incidence of crash, near crash, or other safety critical events, but there is an insufficient quantity of evidence from which to determine what the minimal rest duration is, and other studies somewhat inconsistently suggest that napping for any duration does not improve feelings of fatigue or sleepiness. Minimally acceptable evidence suggests a minimum of 4 to 6.7 hours is needed in the 24 hours before driving, and that a total of at least 8 to 12 is needed in the 48 hours before driving to function well. One study emphasized that both sleep in the 24 hours and total sleep during the 48 hours prior to shift start was important for function.
The findings of each study are summarized in Table 25.

Table 25. Summary of Findings on Duration of Rest Needed to Recover Driving Function

Reference	Year	Duration of Sleep During Shift	Duration of Overnight Sleep	Duration of Restart
Barr et al.[34]	2011		Sleepiness: Drivers with drowsy event slept mean 5 hours, while driver without slept mean 4.75 hours.	
Drowsy Driver Warning System Study[31]	2011		Function: The mean duration of sleep was 5.28 hours before a critical event occurring toward the end of shift, and 6.63 hours overall	
Jovanis et al.[101]	2011			Function: 34-hour restart associated with increased incidence of crash vs. no restart
Naturalistic Truck Driving Study[26]	2011	Function: 30-minute rest (not necessarily sleep) reduced critical event incidence after nap, duration of follow-up 1 hour		
Dorrian and Dawson[29]	2005		Function: Need >6.5 hours in preceding 24 hours and >8 in previous 48 hours	
Perez Chada[25]	2005	Function: 30-minute nap associated with lower safety critical event incident		
Belenky et al.[32] **Balkin et al. 2000[33]**	2003 2000		Function and Sleepiness: Need >4 hours overnight	

Wylie 1998[28] **Wylie 1996*[102]**	1998 1996	Sleepiness: No association		
Hertz[30]	1988		Function: Sleeping 8 hours consecutively was associated with lower fatal crash incidence than sleeping two 4-hour shifts in sleeper berth	
Boiven et al.[27]	NR	Fatigue: No association		

N/A – Not applicable; NR – Not reported

Studies on nonprofessional drivers, consisting primarily of college-aged volunteers, supports the finding that a 30-minute nap can improve driving function in drivers with partial sleep restriction. In four studies, the effect of a 30-minute nap on driving ability was evaluated in drivers with partial sleep restriction (either overnight sleep limited to about five hours, or extended wakefulness with a drive at 2 or 3 a.m.).[103-106] De Valck did not find that taking a nap after restricted overnight time in bed reduced lane drifting during the subsequent morning driving simulation.[106] However, three other studies found that napping improved lane drifting or inappropriate line crossings during early afternoon driving[103] or overnight driving.[104, 105] In a fifth study, Garbarino and colleagues found that police officers who napped before driving on a night shift had a 38 percent greater incidence of crash during their shift.[107]

General research suggests naps shorter than 20 minutes may be long enough to be restorative but short enough that deep sleep sets in, which can cause-post nap grogginess, or 'sleep inertia.'[59, 108] Sleep inertia may be greatest for people with sleep deprivation and for naps lasting longer than 30 minutes, but may not last more than 15 minutes post-nap.[109] However, individual differences, degree of sleep deprivation, and circadian phase (time of day) may influence the efficacy of the nap and duration needed, and for how long the nap benefits last.[108, 109]

Two additional studies investigated the association between overnight duration of rest and driving ability. Unfortunately, these studies do not further inform findings on minimum duration of overnight sleep or rest for safe driving. Cummings et al., who assessed crash records, found that drivers who slept less than nine hours in the previous 24 hours were more likely to crash.[110] Valent et al. [111], found among drivers presenting to the emergency department with road crash injuries, drivers were more likely to crash when they were awake for at least 16 hours or when they worked more than 12 hours in a day.

Key Question 3: How do motorcoach drivers differ from truck drivers in terms of their demographics, job characteristics, work environment, and health status?

The purpose of Key Question 3 is to describe key characteristics of both motorcoach/bus and truck drivers, and then examine whether any differences exist between these two driver types. We were specifically requested to examine the following characteristics:

A. Demographics
B. Job characteristics
C. Work environment
D. Health status and/or disease characteristics.

We have divided Key Question 3 into four major subsections to address each of these characteristics separately. The attributes addressed in each subsection are indicated in Box 1.

Box 1. Topics for Key Question 3A-D

A. Demographics	B. Job Function	C. Work Environment	D. Health-Related Behaviors and Disease Characteristics
• Gender • Race/ethnicity • Age • Education • Income • Marital status • Job tenure	• Roads travelled • Distance travelled • Driving time • Total time worked • Loading requirements • Light work duties • Pre-trip operations • Opportunities to rest	• Control over trip • Interactions with passengers • Violations • Scheduling • Access to health care • Employment/Industry Culture • Potential exposure to harmful substances • Quality of rest/sleep • Opportunity for exercise	• Smoking status • Body Mass Index • Physical activity • Use of stimulants • Alcohol use • General health assessment • HIV/AIDS • Cancer • Cardiovascular disease • Respiratory disease • Sleep disorders • Chronic kidney disease • Endocrine disease • Neurologic disease • Musculoskeletal disease • Mental health/suicide • Sensory (vision or hearing)

Unlike Key Questions 1 and 2, for Key Question 3, we have limited our search for relevant data to literature and other sources of information that pertain exclusively to truck drivers and motorcoach drivers, as well as transit bus drivers due to the paucity of data regarding the latter. Additionally, our search was restricted to include only studies conducted in the United States during the 10 years prior to 2012. These restrictions were deemed necessary to maintain strict relevance to commercial drivers in the United States and in today's society. The retrieval and inclusion criteria are listed in Appendix B and C.

We identified a total of 39 studies that address one or more components of Key Question 3. Table 26 shows which studies provide data for each component of Key Question 3. In the sections that follow, we describe how the evidence base was identified, how the relevant data were abstracted, key attributes of motorcoach/bus and truck drivers, and key findings for each attribute assessed. The design characteristics and quality assessments of the studies, in terms of the epidemiological data they provide (eg, the risk of bias), are provided below.

Table 26. Key Questions Addressed by Included Studies

Primary Reference	Year	Key Question Addressed				Driver Type	
		Demographics KQ3-A	Job Function KQ3-B	Work Environment KQ3-C	Health Behavior & Diseases KQ3-D	Motorcoach/bus	Truck
Anderson & Riley[112]	2008				✓		✓
Beilock[113]	2003	✓	✓	✓			✓
Blanco et al.[114]	2011	✓	✓				✓
Chiu et al.[115]	2011			✓			✓
Chiu et al.[116]	2010			✓	✓		✓
Colt et al.[117]	2004				✓		✓
Couper et al.[118]	2002				✓		✓
Crum et al.[119]	2002	✓	✓	✓	✓	✓	✓
Davis et al.[120]	2007			✓	✓		✓
Dinges & Maislin[80]	2006	✓	✓	✓	✓		✓
Escoto & French[121]	2012	✓	✓	✓	✓	✓	
Fine et al.[122]	2012	✓	✓	✓	✓		✓
Fu et al.[123]				✓			✓
Garshick et al.[124]	2002	✓			✓		✓
Garshick et al.[125]	2008				✓		✓
Howarth[126]	2002	✓	✓	✓		✓	
Jain et al.[127]	2006	✓			✓		✓
Kashima[128]	2003	✓			✓		✓
Laden et al.[129]	2007	✓			✓		✓
Layne et al.[130]	2009	✓	✓	✓	✓		✓
Martin et al.[131]	2009	✓			✓		✓
McCartt et al.[132]	2008	✓	✓	✓			✓
Morrow & Crum[45]	2004	✓	✓	✓			✓
Pack et al.[133]	2002				✓		✓
Reed & Cronin[134]	2003	✓	✓	✓	✓		✓

Primary Reference	Year	Key Question Addressed				Driver Type	
		Demographics KQ3-A	Job Function KQ3-B	Work Environment KQ3-C	Health Behavior & Diseases KQ3-D	Motorcoach/bus	Truck
Robinson & Burnett[135]	2005				✓		✓
Rodriguez et al.[136]	2006	✓	✓				✓
Rodriguez et al.[137]	2003	✓	✓				✓
Sando et al.[138]	2010		✓	✓		✓	
Smith et al.[139]	2006			✓			✓
Smith & Phillips[140]	2011	✓			✓		✓
Solomon et al.[141]	2004	✓	✓	✓	✓		✓
Stasko & Neale[142]	2007		✓	✓	✓		✓
Turner & Reed[143]	2011	✓		✓	✓		✓
Watkins et al.[144]	2009						✓
Whitfield Jacobson et al.[145]	2007	✓			✓		✓
Wiegand et al.[146]	2009				✓		✓
Xie et al.[147]	2011	✓			✓		✓
Zhang et al.[148]	2005				✓		✓
Number of Studies		23	14	17	28	4	36

Characteristics of Included Studies

Key background data and study characteristics of the 39 included studies that address this key question are presented in Table 27 and Table 28. Two primary study designs (cross-sectional and cohort) characterize the studies included in the evidence base of Key Question 3. Although the included studies assess various topics, their commonality is that they provide data in one or more of the four categories that distinguish trends among truck and coach drivers.

Table 27. Evidence Base for Key Question 3

Reference	Year	Study Location	Region/ Scale
Commercial Motor Vehicle Drivers – Truck			
Anderson & Riley[112]	2008	Truck shows and truck stops across U.S.	National
Beilock[113]	2003	Agricultural inspection stations along interstate highways in northern Florida	National
Blanco et al.[114]	2011	2 companies based in Virginia; 2 in North Carolina	National
Chiu et al.[115]	2011	Onsite at 2 unionized trucking terminals, in Carlisle, PA and Chicago, IL, and by mail to 3 unionized trucking companies	National

Reference	Year	Study Location	Region/ Scale
Chiu et al.[116]	2010	25 trucking terminals throughout U.S.	National
Colt et al.[117]	2004	New Hampshire	Regional
Couper et al.[118]	2002	Inspection stations along Interstate 5 at Ashland, OR; U.S. Highway 97 at Klamath Falls, OR; I-5 north of Vancouver, WA; on State Route 14 near Stevenson, WA, and on eastbound Interstate 84 at Cascade Locks, OR	Regional
Crum et al.[119]	2002	1st data set: 5 truck stops. One each in California, Colorado, Georgia, Iowa, and Maryland 2nd data set: 116 trucking companies	National
Davis et al.[120]	2007	36 trucking terminals throughout U.S.	National
Dinges & Maislin[80]	2006	4 large national less-than-truckload (LTL) companies based in Arkansas, Pennsylvania, Ohio, and Kansas	National
Fine et al.[122]	2012	Alabama-based trucking companies	Regional
Fu et al.[123]	2010	Knoxville, TN	Local
Garshick et al.[125]	2008	4 large unionized trucking companies in U.S.	National
Garshick et al.[124]	2002	Demographic data retrieved from personnel records of 4 large national LTL trucking companies in U.S. Exposure assessed at 2 large terminals in Atlanta and 4 small terminals in New England. Health/work survey sample from 1 large trucking terminal Atlanta, GA.	National/ Regional
Jain et al.[127]	2006	3 national trucking companies in U.S.	National
Kashima[128]	2003	Chevron Products Co. sites across U.S.	National
Laden et al.[129]	2007	4 national trucking companies	National
Layne et al.[130]	2009	Truck stops in 3 rural Ohio areas (London, Beaverdam, Jeffersonville)	National
Martin et al.[131]	2009	Large national transportation logistics company	National
McCartt et al.[132]	2008	Weigh stations off I-80 in western Pennsylvania and I-84 in northwestern Oregon	National
Morrow & Crum[45]	2004	116 companies nationwide	National
Pack et al.[133]	2002	Drivers living in 50-mile radius of University of Pennsylvania in Philadelphia	Regional
Reed & Cronin[134]	2003	Louisville, KY Mid-America Truck Show	Unknown
Robinson & Burnett[135]	2005	Data from 28 U.S. states	National
Rodriguez et al.[136]	2006	Drivers of J.B. Hunt, one of three nonunion truckload trucking and logistics firms operating in North America	National
Rodriguez et al.[137]	2003	Drivers of J.B. Hunt, one of three nonunion truckload trucking and logistics firms operating in North America	National
Smith et al.[139]	2006	36 randomly sited large truck freight terminals in the U.S.	National
Smith & Phillips[140]	2011	Online survey	National
Solomon et al.[141]	2004	16 truck stops (14 states): Knoxville, TN; Glade Spring, VA; Girard, OH; Rochelle, IL; Portage, WI; Walcott, IA; Des Moines, IA; Grand Island, NE; Big Springs, NE; Belgrade, MT; Laramie, WY; Commerce City, CO; Oak Grove, MO; Effingham, IL; Carlisle, PA; and Elkton, MD	National
Stasko & Neale[142]	2007	Michigan truck stops	National

Reference	Year	Study Location	Region/ Scale
Turner & Reed[143]	2011	6 trucks stops in U.S.	National
Watkins et al.[144]	2009	1 occupational medical clinic for a large, national motor carrier in U.S.; site unknown	National
Whitfield Jacobson et al.[145]	2007	A Midwestern franchised truck-stop restaurant	Unknown
Wiegand et al.[146]	2009	3 long-haul driving operations; locations unknown	Unknown
Xie et al.[147]	2011	Lebanon, TN	Regional
Zhang et al.[148]	2005	Iowa	Regional
Commercial Motor Vehicle Drivers – Motorcoach/bus			
Crum et al.[119]	2002	3rd data set: Data 122 drivers and 66 motorcoach firms	Regional
Escoto & French[121]	2012	4 transit garages in a Midwestern U.S. city	Local
Howarth[126]	2002	State-funded agency in Northeast U.S.	Local
Sando et al.[138]	2010	1st dataset: 266 transit operators from 6 agencies in Florida: Jacksonville, Orlando, Gainesville, Tallahassee, Live Oak and Lake Butler 2nd dataset: Records from four transit agencies and Florida – two large and two medium size agencies – totaling 972 transit drivers	Regional

Table 28. Study Design Characteristics for Key Question 3

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
Commercial Motor Vehicle Drivers – Truck									
Anderson & Riley[112]	2008	Cross-sectional non-interventional study	987	Work-related violence surveys at truck stops and truck shows across U.S.	Convenience	NR	Truck drivers with a CDL Spend one or more nights away from home > 21 Speak English	NR	Determine standards of care for substance abuse and alcohol use in long-haul truck drivers.
Beilock[113]	2003	Cross-sectional	1,624	Anonymous interviews conducted by the University of Florida students	Convenience	> 90%	Drivers of long-distance refrigerated trailers stopping at agricultural inspection stations along interstates in northern Florida	NR	To assess whether driving schedules encourage violations in Hours-of-Service regulations and/or speed limits.
Blanco et al.[114]	2011	Naturalistic data collection	97 (96 provided demographic data); 75 primarily long-haul, and 21 line-haul	Naturalistic: Data collected as study participants drove instrumented company trucks during normal runs; daily activity registers	NR	NR	Long-haul and line-haul truck drivers working for 1 of 4 for-hire carriers, 2 of which were based in Virginia, and 2 of which were based in North Carolina	NR	To analyze the average workday of long- and line-haul drivers, and the impact of time-on-task on safety-critical events as a function of driving hours, work hour, and driving breaks.
Chiu et al.[115]	2011	Cross-sectional	97 long-haul and pickup and delivery	Blood samples, health and work surveys	Convenience	NR	Non-smoking drivers at unionized trucking companies in the U.S.	Smokers	Assess the association between second-hand smoke exposure in nonsmoking U.S. trucking industry workers.
Chiu et al.[116]	2010	Cross-sectional	113 long-haul and pickup and delivery	Health surveys; monitoring by passive personal samplers of	Convenience	NR	Workers at 25 trucking terminals throughout U.S. with at least 100	NR	Evaluate the factors influencing workplace secondhand smoke exposures in the U.S.

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
				vapor-phase nicotine in the breathing zone			employees, representing 3 large, unionized trucking companies		unionized trucking industry.
Colt et al.[117]	2004	Population-based case-control study	47 tractor-trailer driver cases; 25 tractor-trailer driver controls. 424 cases and 645 controls employed in various industries	Occupational histories obtained from detailed in-person interviews, mailed surveys	Convenience	NR	Cases: New Hampshire residents, ages 25–74, diagnosed with primary bladder cancer from July 1, 1994 to June 30, 1998 Controls: Subjects matched to cases by age and gender	Cases: Unlisted phone number, don't speak English	To identify occupations with excess bladder cancer risk in New Hampshire, where bladder cancer mortality rates have been elevated for decades.
Couper et al.[118]	2002	Cross-sectional	822	Anonymous and voluntary urine specimens were tested using immuno-assay and GCMS techniques	Convenience	80% compliance; 19% refusal rate; 1% unsuitable for analysis	Tractor-trailer drivers stopped at inspection sites in Oregon and Washington	NR	
Crum et al.[119]*	2002	Cross-sectional	**1st data set:** 502	Survey	Random	Unknown	Over-the- road (long-haul) drivers	NR	To determine how scheduling practices affect driver fatigue.
		Cross-sectional	**2nd data set:** 279 drivers	Surveys of companies, drivers	Stratified – samples from 3 categories: top performers, average performers, and poor performers	374 (66.1%) of 566 companies contacted agreed to participate 116 (31%) returned usable survey sets 24.8% for poor performers, 38.7% for average performers	Over-the-road (long-haul) drivers Firms had to have accurate census data on location, safety performance record, and at least 4 drivers	NR	
Davis et al.[120]	2007	Retrospective cohort	349 long-haul drivers	Driver exposure to 3 components of diesel exhaust	Convenience	NR	Drivers of diesel long-haul and P&D trucks at 36 trucking	NR	To assess how exposure of combustion particles to complement

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
				combustion particles (PM, elemental carbon, and organic carbon) measured by in-cab sampling box for 1 week per site; health and work survey. PM and carbon monoxide data also collected from EPA monitors within 50–100 km radius around each geocoded terminal address.			terminals throughout U.S.		epidemiologic data on lung cancer mortality for workers in the U.S. trucking industry.
Dinges & Maislin[80]	2006	Cross-sectional	2,280 (1,128 million-milers and 1,152 non-million-milers)	Self-administered mail surveys	Stratified random sampling of returned surveys	40%	Teamster LTL drivers from 4 large MFCA companies (including both million mile and non-million mile drivers)	NR	Identify factors related to causes of fatigue and ways to manage fatigue in Teamster commercial drivers
Fine et al.[122]	2012	Cohort study	50	Survey, brief physical exam, brief computerized cognitive test, driving simulation	Convenience	N/A	Long-haul drivers who slept at least 3 nights/week in sleeper berths of their trucks and were deemed medically fit per USDOT standards, were age 21 to 65, had a valid, state-issued CDL, owned a cell phone and were able to read, write, and	1) A diagnosis of sleep apnea 2) Self-reported routine and habitual use of sedating or hypnotic medications, illicit drugs, or alcohol	Examine the interaction of cognitive and technological aspects of distracted driving as well as physical health among commercial drivers

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
							speak English		
Fu et al.[123]	2010	Cross-sectional	27 trucks	Measurements of noise level, whole-body vibration from driver and passenger seats, and in-cab air quality	Convenience	N/A	N/A	N/A	Measure several factors inside the cab of heavy-duty diesel vehicles that may affect the health and performance of drivers; test model year trucks available at the time from at least four manufacturing companies.
Garshick et al.[125]	2008	Retrospective cohort study	31,135 males only	Trucking company records; National Death Index (National Center for Health Statistics); industrial hygiene review and exposure measurements to identify jobs associated with current and historical use of diesel-, gas-, and propane-powered vehicles	Convenience	NR	Men ≥ 40 years of age in 1985 with at least 1 year of work in a trucking industry job	NR	To assess the association of lung cancer mortality and measures of vehicle exhaust exposure
Garshick et al.[124]	2002	Cross-sectional feasibility study	17,300 male long-haul drivers from personnel record; 107 male long-haul drivers	Demographic data from computerized personnel records of 4 large national LTL trucking companies; health/ work	Convenience	Survey response rate: 49.8%	Male long-haul drivers at one of 4 large unionized LTL companies	NR	Test the feasibility of identifying a population exposed to diesel exhaust in which small to moderate excesses in lung cancer could be estimated with reasonable precision and to develop a

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
			(company job title) from surveys	survey mailed to Atlanta, Georgia, workers. PM2.5 exposure assessed at 2 large terminals in Atlanta and 4 small terminals in New England using Personal Environmental Monitor					strategy to provide quantitative estimates of current and past exposures.
Jain et al.[127]	2006	Retrospective cohort study	1,130 long-haul drivers	Mailed survey, company records	Random	45.5% for long-haul drivers Response rate for all job positions was higher among whites than among blacks and Hispanics, and responders were older than non-responders	Unionized trucking industry employees working at 3 U.S. companies in 2002 or retired from these companies between 1997 and 2002	Females, non-whites excluded due to low numbers; surveys missing smoking data excluded	Assess the relationship between job title and smoking behavior in trucking industry workers as part of a study on occupational exposures and lung cancer.
Kashima[128]	2003	Cross-sectional	109	Functional capacity evaluations by clinicians	NR	N/A	Chevron Products Co. fuel-truck drivers required to undergo functional capacity evaluations	NR	Assess a petroleum company's experience in implementing a comprehensive medical fitness-for-duty program for professional truck drivers.
Laden et al.[129]	2007	Retrospective cohort study	36,299	Trucking company records; National Death Index (National Center for Health Statistics)	Convenience	N/A	Male intercity long-haul drivers, city pickup and delivery (P&D) drivers, and combination drivers (loading dock workers who also drive P&D trucks)	Females excluded due to small numbers	Provide insight into mortality patterns associated with job-specific exposures by examining rates of cause-specific mortality compared with the general U.S. population.
Layne et	2009	Descriptive	50	Surveys;	Convenience	NR	Male and female	NR	Determine whether

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
al.[130]		cross-sectional survey		interviews with 2 male drivers and 1 female driver			long-haul truck drivers, defined as truckers who were away from home overnight each week, and were able to read, write, and speak English		health conditions and health care access differ between male and female long-haul truck drivers.
Martin et al.[131]	2009	Retrospective cross-sectional	2,950	Demographic data from logistics company records. Health care claims data from the 3 commercial insurers administering the company's health benefits, and 1 pharmacy benefit management company	NR	N/A	Male truck drivers who had Department of Transportation (DOT) physical in 2004 and had been eligible for health benefits for 1 continuous year after DOT physical.	Under-weight (BMI 18.5) truckers Females	Quantify health care costs of truck drivers across categories of normal weight, overweight, and obese.
McCartt et al.[132]	2008		1,921	Anonymous person-to-person interviews of drivers of large trucks, conducted by trained inter-viewers at 2 weigh stations. Drivers were paid $10 to participate.	Convenience	88%-98%	Drivers who regularly made trips requiring them to spend at least one night away from home.	Overweight drivers Inspected drivers Known local trucks	Assess changes in long-distance truck drivers' reported work schedules and reported fatigued driving after the rule change on Jan. 4, 2004.
Morrow & Crum[45]	2004	Cross-sectional	116	Surveys distributed to 3 "typical" drivers	NR	Of 566 companies contacted by phone, 66.1% agreed to	Drivers at firms in Office of Motor Carriers Census file	NR	Examine the effects of potentially fatigue-inducing factors

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
				at 116 firms; single survey kept from each company		participate (374). Of these, 116 (20.5%) returned usable surveys, with 32 from top safety-performing firms, 53 from average firms, and 31 from poor performing firms. At least 1 of 3 drivers at 116 firms returned survey.	and Motor Carrier Safety Status Measurement System database SafeStat (Firms must have 4 or more drivers.) Carriers placed in 3 groups based on safety rating; sample carriers chosen randomly from these		inherent in truck driving work and company safety management in explaining: (a) drivers driving while fatigued, (b) the frequency of close calls due to fatigue, and (c) actual crashes among CMV drivers.
Pack et al.[133]	2002	Cross-sectional	1,391	Multivariable Apnea Prediction (MAP); surveys; assessment of reaction times, performance lapses, and lane tracking ability; sleepiness scales	Random	31.5%	NR	NR	Assess prevalence of sleep apnea among commercial truck drivers, potential risk factors, and its impact on driving performance.
Reed & Cronin[134]	2003	Descriptive, cross-sectional study	284	Self-administered surveys at booth at truck show. Drivers given tote bag, entered in drawing for necklace.	Convenience	N/A	English-speaking female long- haul truck drivers (truckers who were away from home overnight each week) who were at a truck show	Surveys missing at least 25% of data	A descriptive study was conducted to identify health conditions, health care access, and driving environments of female drivers.
Robinson & Burnett[135]	2005	Retrospective cohort	13,241 black long-haul drivers and 74,315 white long-haul drivers	Occupation and industry-coded U.S. mortality data from 1979 to 1990 for ages 15–90	Convenience	N/A	NR	NR	Calculate proportional mortality ratios for heart disease and lung cancer for short and long-haul truck drivers
Rodriguez et al.[136]	2006	Cross-sectional	2,368	Human resources,	Convenience	N/A	Unscheduled over-the-road, dry-van	NR	Examine the effect of a pay increase on the

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
				operations, and safety data			tractor-trailer drivers for J.B. Hunt		safety outcomes of truck drivers.
Rodriguez et al.[137]	2003	Cross-sectional	11,540	Human resources, operations, and safety data	Convenience	N/A	Unscheduled over-the-road, dry-van tractor-trailer drivers for J.B. Hunt	NR	Examine the role of human capital and occupational factors, along with demographic characteristics, on the crash frequency of truck drivers.
Smith et al.[139]	2006	Cohort study	251 long-haul drivers in particulate study	Trucking company records; box samplers to measure particulate exposure in different work areas and upwind in terminal yard for background data	NR	NR	Workers at 36 large truck freight terminals (>100 employees) that were selected based on regional distribution across U.S	NR	Assess particulate exposures in the U.S. trucking industry.
Smith & Phillips[140]	2011	Cross-sectional	595	Online anonymous survey (version of Berlin Questionnaire) on Truckers for a Cause Chapter of Alert Well and Keeping Energetic of the American Sleep Apnea Association Website	Convenience	Unknown	Individuals who completed online survey on risk factors for sleep apnea	N/A	Assess truck drivers' risk of OSA prior to their required FMCSA physicals.
Solomon et al.[141]	2004	Cross-sectional	521	Anonymous self-administered surveys were	Convenience	41% average at all sites combined; varied from 30% to	Long-haul drivers at 1 of 16 large truck stops (truck parking	Employment as a local driver without overnight routes,	Assess access to healthcare services among long-distance

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
				completed at 16 truck stops in 14 states across the country		57% among sites	for 100+) in 14 states	employment only on a ‘‘dedicated run’’ (same route continuously), and residence outside U.S.	truck drivers.
Stasko & Neale[142]	2007	Cross-sectional	30	Anonymous survey conducted by interviewer	Convenience	34%	Long-haul drivers at Michigan truck stops	Short-haul drivers	A pilot study to explore health care needs and access issues of long-distance truck drivers, establishing a foundation for further study
Turner & Reed[143]	2011	Cross-sectional, non-experimental	300	Height, weight measured by research team; self-administered surveys completed	Convenience	NR	Commercial long-distance drivers who operate heavy trucks or tractor-trailers to transport goods, who had been working as a commercial truck driver for at least 2 years; were 23 years or older; spent a minimum of 2 days overnight on the road per week or 8 days overnight per month; were free of infection and other illnesses within the 2 weeks prior to enrollment	Having a pacemaker or other implanted device Pregnant Non-English speaking More than 30 percent of survey questions not answered	Examine the exercise habits and perceived barriers to exercise of a convenience sample of commercial truck drivers.
Watkins et al.[144]	2009	Consecutive case series	346	Commercial driver medical exam	Convenience	N/A	NR	NR	To compare the accuracy of portable monitoring for obstructive sleep apnea with polysomnography in commercial drivers
Whitfield	2007	Descriptive,	92	Height, weight,	Convenience	92%	Patrons of a	NR	Compare truckers’

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
Jacobson et al.[145]		cross-sectional pilot study		other anthropometrics measured by health professional; self-administered surveys			franchised Midwestern truck stop restaurant who identified themselves as truck drivers		anthropometrics with recommended guidelines; and assess eating/exercise habits, importance of healthful food choices, and attitudes about restaurants' provision of healthful options.
Wiegand et al.[146]	2009	Long-term naturalistic	103	Drivers measured and weighed; data collection equipment in trucks gave vehicle motion data, video of driver and driving environment	Convenience	NR	NR	NR	Explore the relation of commercial truck drivers' body mass index (BMI) to fatigued driving episodes and involvement in safety-critical events.
Xie et al.[147]	2011	Cross-sectional retrospective case-control study	1,890	Review of commercial driver medical exam (CDME) records at an occupational health clinic	NR	N/A for demographic data	CMV drivers who presented for CDMEs at an occupational health clinic in Lebanon, TN, and who had complete medical exam records	NR	Identify factors associated with obstructive sleep apnea (OSA) risk during commercial driver medical examinations.
Zhang et al.[148]	2005	Population-based case-control study	376 histologically confirmed incident pancreatic cancer cases and 2434 control subjects	State Health Registry of Iowa records for cases, computerized state driver's license records and U.S. Centers for Medicare & Medicaid Services listings	Convenience	Overall, 88% Controls under age 65: 82% Controls age 65 and over: 79%	Cases on State Health Registry of Iowa, diagnosed between August 1985 and December 1987, age 40-85, Iowa residents; controls frequency matched by gender and 5-year age groups; under-65 controls picked	No previous diagnosis in cases or controls of malignant neoplasm except for non-melanoma skin cancer	Assess pancreatic cancer risk among truck drivers.

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
				for controls; job history info from subjects or next-of-kin via surveys and phone interviews			randomly from driver's license records and age 65 and older from U.S. Centers for Medicare & Medicaid Services		
Commercial Motor Vehicle Drivers – Coach Drivers									
Crum et al.[119]*	2002	Cross-sectional	3rd data set: Group one: 122 drivers Group two: 66 companies	Surveys of companies, drivers	Stratified – samples from 3 categories: top performers, average performers, and poor performers	Group 1: 122 drivers of 66 participating companies. Group 2: 150 (93.2%) of 161 companies contacted agreed to participate; 66 (44%) of these returned usable survey sets; 34.9% poor per-formers; 52.3% average performers	Firms had to have accurate census data on location, safety performance record, and at least 2 drivers	NR	Develop a better understanding of how the scheduling practices of motor carrier firms affect driver fatigue via three separate studies.
Escoto & French[121]	2012	Cross-sectional	796	Self-administered surveys; height & weight measured by research staff	Convenience	Rate from 4 garages ranged from 69% to 84%	Urban bus operators at 4 transit garages in a Midwestern U.S. city	Must have completed baseline measurement assessment	Examine the prevalence of unhealthy and healthy weight control behaviors used by urban bus operators and examine associations between use of unhealthy weight control behaviors and work-related and sociodemographic variables.
Howarth[126]	2002	Cross-sectional	102 (Group one: 30 straight-shift drivers Group two:	Anonymous written surveys	NR	149 (58%) of 259 operators technically available to answer survey; however, number actually	Transit bus operators at a state-funded agency in the Northeast U.S. who were not on-call	Missing responses totaling 1 or more pages in survey Missing work schedule times	Investigate the relationship between work shift schedules, sleep length, and various measures of

Reference	Year	Study Design	Participants N =	Data Collection Method (Survey, Records, etc.)	Sample Type (Random, Convenience, etc.)	Response Rate	Inclusion Criteria	Exclusion Criteria	Study Objective
			72 split-shift workers)			present during survey distribution unknown	workers or on irregular schedules or schedules changed to fill in for long-term absences or vacations; unambiguous answers to survey	and conflicting responses Workers at agency <1 yr Workers in current schedule <1 mo Work hours not verifiable More than 1 week off during survey period Fixed-response replies	fatigue in transit bus operators
Sando et al.[138]	2010	Cross-sectional	266 transit drivers from 6 Florida agencies	Survey	Convenience	NR	Bus operators at six FL transit agencies	NR	Examine safety implications of current hours of service regulations used for transit operators in the state of Florida.
			972 transit drivers from 4 Florida agencies	Work schedules and incident reports of drivers	Stratified	Data received on all workers	FL transit agencies were selected based on their willingness to participate and availability of electronic incident report databases that could be exported to a Microsoft Access database.	All nonpreventable crashes and collisions were excluded.	

BMI – Body mass index; CDL— Commercial driver's license; LTL – Less than truckload; MFCA – Motor Freight Carriers Association; N/A – Not applicable; NR – Not reported; P&D – Pickup and delivery;
* The study sought to be representative of all over-the-road commercial truck drivers; however, the population of such drivers cannot be specified (ie, there is no directory of all truck drivers). Consequently, sampling was conducted in a manner to avoid systematic bias in the selection of drivers.

Risk of Bias Assessment

One assessment instrument was used to assess the quality of the studies included in the evidence base for Key Question 3: the Joanna Briggs Institute (JBI) Descriptive/Case-Series Critical Appraisal Tool. Key attributes of a study that are assessed with this instrument relate to how the sample for the study was selected, whether confounding factors were identified, outcome data employed objective or subjective criteria, etc.

Following the application of the instrument, each study was then classified with an overall risk of bias. Classifications were assigned as follows.

- "Low" risk of bias was provided for studies in which all or most of the checklist criteria had been fulfilled. This grading also was given to those studies where categories weren't fulfilled but the conclusions were unlikely to change.
- "Moderate" risk of bias was provided for those studies that had some of the checklist criteria fulfilled or for those studies where categories had not been fulfilled, or not adequately described, but the conclusions were unlikely to alter.
- A "High" risk of bias was provided for studies that had few or no checklist criteria fulfilled and/or the conclusions were likely or very likely to alter.

Complete details of our quality assessment can be found in the study summary tables presented in Appendix E. Our analysis using the JBI Descriptive/Case-Series Critical Appraisal Tool concluded that overall bias of the included studies was moderate to high. The findings of our quality assessment for the included studies comprising the evidence base of Key Question 3 are summarized in Table 29.

Table 29. Risk of Bias Assessment for Key Question 3

Reference	Year	Quality Scale Used	Bias Risk
Anderson & Riley[112]	2008	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Beilock[113]	2003	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Blanco et al.[114]	2011	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Chiu et al.[115]	2011	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Chiu et al.[116]	2010	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Colt et al.[117]	2004	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Couper et al.[118]	2002	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Crum et al.[119]	2002	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Davis et al.[120]	2007	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Dinges & Maislin[80]	2006	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Escoto & French[121]	2012	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Fine et al.[122]	2012	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Fu et al.[123]	2010	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Garshick et al.[125]	2008	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Garshick et al.[124]	2002	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Howarth[126]	2002	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate

Reference	Year	Quality Scale Used	Bias Risk
Jain et al.[127]	2006	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Kashima[128]	2003	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Laden et al.[129]	2007	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Layne et al.[130]	2009	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Martin et al.[131]	2009	JBI Descriptive/Case-Series Critical Appraisal Tool	High
McCartt et al.[132]	2008	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Morrow & Crum[45]	2004	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Pack et al.[133]	2002	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Reed & Cronin[134]	2003	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Robinson & Burnett[135]	2005	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Rodriguez et al.[136]	2006	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Rodriguez et al.[137]	2003	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Sando et al.[138]	2010	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Smith et al.[139]	2006	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Smith & Phillips[140]	2011	JBI Descriptive/Case-Series Critical Appraisal Tool	Moderate
Solomon et al.[141]	2004	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Stasko & Neale[142]	2007	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Turner & Reed[143]	2011	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Watkins et al.[144]	2009	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Whitfield Jacobson et al.[145]	2007	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Wiegand et al.[146]	2009	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Xie et al.[147]	2011	JBI Descriptive/Case-Series Critical Appraisal Tool	High
Zhang et al.[148]	2005	JBI Descriptive/Case-Series Critical Appraisal Tool	High

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To further distinguish biases among the studies included in this report, Table 30 identifies our primary issues of concern regarding Key Question 3.

Table 30. Quality Assessment for Key Question 3

Reference	Year	Primary Issues of Concern
Beilock[113]	2003	• Unknown number of drivers from Canada • Refrigerated rigs chosen for their unusually tight schedules • Refrigerated trucks make up only about 10% of North American truck fleet, study says • Hours-of-service rules have changed since study • Driver mileage estimates may be wrong
Blanco et al.[114]	2011	• Demographic data not separated by line-haul vs. long-haul drivers • Study subjects were volunteers, so results cannot be generalized to entire truck driver population
Chiu et al.[115]	2011	• P&D and long-haul driver data not separated • Plasma cotinine level generally reflects secondhand smoke exposure in previous 1–2 days only
Chiu et al.[116]	2010	• P&D and long-haul driver data not separated • Smoking status self-reported
Colt et al.[117]	2004	• Cases more likely than controls to have a history of cigarette smoking • Small sample • No female tractor-trailer drivers in sample

Reference	Year	Primary Issues of Concern
Couper et al.[118]	2002	• 19% refusal rate • Drivers may have heard about and avoided inspection or changed drivers • By analyzing urine, one is unable to determine time of drug ingestion and whether driver was impaired at time of driving • Urine-to-blood-alcohol conversion can overestimate blood alcohol level • Drug screening method was not comprehensive
Crum et al.[119]	2002	• Self-reported survey data • Stratified sample for 2nd and 3rd data sets may skew data • Safety directors chose some of participants for 2nd data set
Davis et al.[120]	2007	• Window status (open or shut) not recorded but estimated based on carbon dioxide-temperature differential • Much of smoking data missing • Route information not provided
Dinges & Maislin	2006	• Self-reported survey data • Limited to Teamster drivers
Escoto & French[121]	2012	• Self-reported survey data • Urban bus drivers
Fine et al.[122]	2012	• Small sample size • Simulated driving may not reflect real driving • Driving simulation all done at night; circadian effects possible
Fu et al.	2010	• Small sample size • No drivers' perspective on the trucks tested (used only measurements) • Trucks were new and not representative of all trucks on the road
Garshick et al.[125]	2008	• Sampling bias • Outcomes of people who withdrew not described/included in analysis
Garshick et al.[124]	2002	• Males only
Howarth	2002	• Data comes from one company • Low participation rate • Number of useable surveys low
Jain et al.[127]	2006	• White males only • Different response rates for different ages • Low response rate overall
Kashima[128]	2003	• Fuel truck driving and its demographics may differ significantly from long-haul driving
Laden et al.[129]	2007	• Males only • Sample includes P&D and combination drivers • Mortality, not prevalence • Healthy worker effect
Layne et al.[130]	2009	• Small convenience sample • Women overrepresented, so other characteristics cannot be generalized to all drivers • Limited availability of drivers meant repeated sampling attempts • High refusal rate due to workers being on job • Data self-reported • Blacks, Hispanics underrepresented in sample
Martin et al.[131]	2009	• Males only • Sample includes intermodal and dedicated contract drivers (local and regional routes)
McCartt et al.[132]	2008	• "Green light" program in Oregon allowed some truckers to bypass weigh station, potentially skewing data
Morrow & Crum[45]	2004	• Low percentage of firms agreed to participate • Safety directors chose participants • Data self-reported

Reference	Year	Primary Issues of Concern
		• Measures without established validity used • Reliance on single item measures for independent variables
Pack et al.[133]	2002	• Study may be using terms "CDL holders" and "commercial truck drivers" interchangeably, so sample may include coach, other drivers • Data from tech brief only; full study not located
Reed & Cronin[134]	2003	• Females only • Self-selected and self-reported • Healthy worker effect • Documented proof of driver status not required
Robinson & Burnett[135]	2005	• No direct data for smoking available • Data isn't current • Mortality, not prevalence • Healthy worker effect • Cause of death and occupation misclassifications on death certificates likely
Rodriguez et al.	2006	• Data comes from one company.
Rodriguez et al.	2003	• Data comes from one company.
Sando et al.[138]	2010	• Study does not report number of those who rejected being surveyed • No definition is provided for transit driver (long distance, regional or local drivers)
Smith & Phillips[140]	2011	• Self-selected sample – likely to over-represent those at higher risk of OSA • Type of truck driver not specified • Online survey participants may not have been drivers at all • Subjects may have taken survey more than once
Solomon et al.[141]	2004	• Intentional oversampling of East-West corridor and larger truck stops • Surveys administered during busiest time of day • Single corporation overrepresented • Healthy worker effect • High refusal rate due to workers being on job
Stasko & Neale[142]	2007	• 4 subjects from Canada • Small sample size • Unionized truckers did not participate • Many truckers expressed concern study was a ploy to get them to admit violations • Time constraints may have stopped more ambitious drivers from participating
Turner & Reed[143]	2011	• Convenience sample, so results cannot be generalized to entire truck driver population • Most data self-reported • Perception of barriers to exercise may differ from reality
Watkins et al.[144]	2009	• Sampling bias, single occupational medicine clinic • Confounding factors not identified • Outcomes of people who withdrew not described/included in analysis
Whitfield Jacobson et al.[145]	2007	• Small, convenience sample at 1 site makes sample bias likely • Some declined to participate due to time constraints, fatigue, or lack of interest
Wiegand et al.[146]	2009	• Participants could not wear eyeglasses • Self-selected participants
Xie et al.[147]	2011	• Review of records at a single clinic limits generalizability
Zhang et al.[148]	2005	• Surveys, phone calls on job history, exposures were taken by proxies for 90% of cases and 10% of controls • Sampling bias • Outcomes not assessed using objective criteria • Outcomes of people who withdrew not described/included in analysis

P&D – Pickup and delivery

Key Question 3A: Demographics

This subsection provides a summary of seven key demographic attributes for motorcoach/bus and truck drivers. They are:

1. Gender
2. Race/ethnicity
3. Age
4. Education
5. Income
6. Marital status
7. Job tenure

Identification of Evidence Base

Database search strategies for Key Question 3A are provided in Appendix A. Our searches identified a total of 1,886 references that appeared to be relevant to this key question. Following application of the retrieval criteria for this question (refer to Appendix B), 51 full-length articles were retrieved and read in full, and 23 were determined to meet our inclusion criteria (refer to Appendix C). Table D-1 of Appendix D lists the 28 articles that were excluded along with the rationale for their exclusion.

Note: This section is supplemented by a brief description of data from the Bureau of Labor Statistics (BLS) for five of the seven demographic attributes: gender, race/ethnicity, age, education, and income. BLS data were not available for marital status or job tenure, as the BLS only provides data for these attributes at the industry level, not the occupational level. More detailed BLS data tables are included in Appendix H.

The study selection process for Key Question 3A is illustrated in Figure 7.

Figure 7. Development of Evidence Base for Key Question 3A

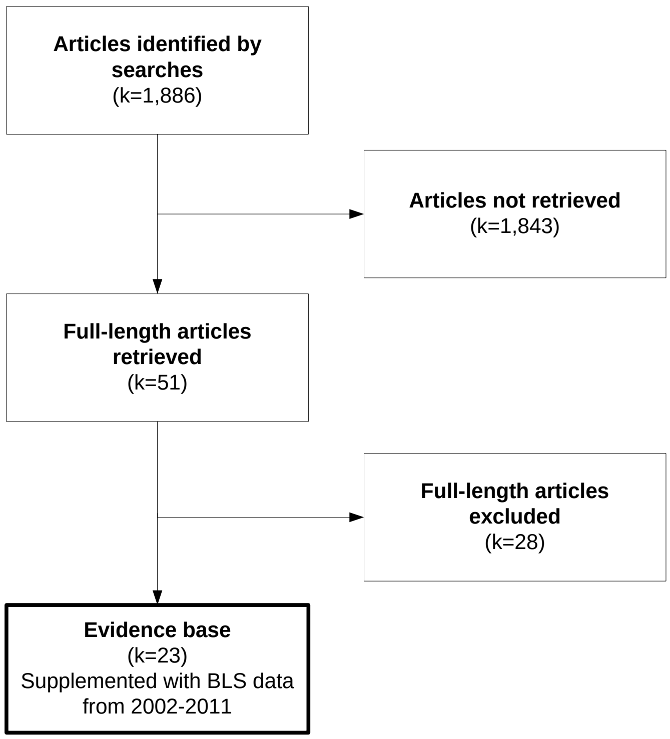


Table 31 identifies the studies utilized in each of the seven demographic attributes along with those attributes provided by the BLS data. Studies listed in this table are further segmented by type of driver (eg, truck drivers or motorcoach/bus drivers).

Table 31. Methods for Assessing Demographic Characteristics Key Question 3A

Reference	Year	Demographic Characteristics Reported						
		Gender	Race/Ethnicity	Age	Education	Income	Marital Status	Job Tenure
Commercial Motor Vehicle Drivers - Truck								
Bureau of Labor Statistics[53]	2002-11	✓	✓	✓	✓	✓		
Beilock[113]	2003			✓				✓
Blanco et al.[114]	2011	✓		✓	✓			✓
Crum et al.[119]*	2002	✓		✓				✓
Dinges & Maislin[80]	2006	✓	✓	✓			✓	✓
Fine et al.[122]	2012	✓	✓	✓	✓		✓	
Garshick et al.[124]	2002							✓
Jain et al.[127]	2006			✓				
Kashima[128]	2003	✓						
Laden et al.[129]	2007		✓	✓				✓

Reference	Year	Demographic Characteristics Reported						
		Gender	Race/Ethnicity	Age	Education	Income	Marital Status	Job Tenure
Layne et al.[130]	2009			✓	✓	✓	✓	
Martin et al.[131]	2009		✓	✓				
McCartt et al.[132]	2008	✓		✓				
Morrow & Crum[45]	2004	✓		✓				✓
Reed & Cronin[134]	2003		✓	✓			✓	✓
Rodriguez et al.[136]	2006	✓	✓	✓			✓	✓
Rodriguez et al.[137]	2003	✓	✓	✓			✓	
Smith & Phillips[140]	2011	✓						
Solomon et al.[141]	2004	✓	✓	✓	✓	✓	✓	
Turner & Reed[143]	2011	✓	✓	✓				
Whitfield Jacobson et al.[145]	2007	✓		✓				✓
Xie et al.[147]	2011	✓		✓				
Commercial Motor Vehicle Drivers – Motorcoach/bus								
Crum et al.[119]*	2002	✓		✓				✓
Escoto & French[121]	2012	✓	✓	✓	✓	✓		
Howarth[126]	2002	✓		✓			✓	✓
Total		**16***	**10**	**20***	**5**	**3**	**8**	**11***

*Crum et al., 2002, is one article represented in both truck and motorcoach/bus driver sections.

Data Abstraction and Evidence Base Description

Characteristics of BLS Data

The BLS is the principal federal agency responsible for measuring labor market activity, working conditions, and price changes in the economy. Its mission is to collect, analyze, and disseminate essential economic information to support public and private decision-making.

Several programs at the BLS provide significant amounts of population-level data for specific demographic [149] and occupational groups. Of relevance to Key Question 3A are the *Current Population Survey*, which provides demographic characteristics of the labor force by occupation category, and the Occupational Employment Statistics Query System (OES) and the *National Compensation Survey*, both of which provide hourly wage and annual income data by occupational category.

The *Current Population Survey* data is derived from a monthly household survey and provides comprehensive information on the employment and unemployment of the population classified by age, sex, race, and ethnic origin, as well as other characteristics, such as educational attainment and veteran status. The age data are limited to persons of working age, defined as 16 years and older. Data on race generally are for blacks and whites. Data on ethnicity are confined to information on persons of Hispanic origin. Data from this survey are limited to occupations that include the populations of interest in this report (ie, commercial motorcoach/bus and truck drivers), but are not exclusive to these populations, which limits their relevance. They are:

- **Bus Drivers** encompass the following two occupations: 53-3021 Bus Drivers, Transit and Intercity (which includes coach drivers), and 53-3022 Bus Drivers, School or Special Client. *Note: Data for coach drivers could not be separated*.
- **Driver/Sales Workers and Truck Drivers** encompass the following three occupations: 53-3031 Driver/Sales Workers, 53-3032 Heavy and Tractor-Trailer Truck Drivers, and 53-3033 Light Truck or Delivery Services Drivers. *Note: Data for heavy and tractor-trailer truck drivers could not be separated.*

Both the OES and the National Compensation Survey provide detailed hourly wage and annual income data by occupation for a variety of geographical regions as well as at a national level. Different from the Current Population Survey, these datasets provide information at a more detailed occupational level. For these surveys, data are reported over time for the following occupational categories:

- **Bus Drivers**: 53-3021 Bus Drivers, Transit and Intercity (which includes coach drivers)
- **Truck Drivers**: 53-3032 Heavy and Tractor-Trailer Truck Drivers

BLS applies statistical data quality principles provided in guidance from the Office of Management and Budget (OMB Statistical Policy Directives, for example), as well as the National Research Council's Principles and Practices for a Federal Statistical Agency. Moreover, all BLS data are subjected to a multi-stage review before they are disseminated to the public.

BLS data for Key Question 3A cover the period of 2002 through 2011. Although the BLS data provide a comprehensive cross-section of demographic characteristics over time, because the data are not specific to the target populations of interest in this report (with the exception of income data), the relevance of the data is limited. As such, we only briefly describe relevant demographic characteristics for the above categories of drivers in the sections that follow. Interested readers will find a more detailed representation of BLS data for these driver categories in Appendix H but are cautioned about their generalizability to commercial motorcoach/bus and truck drivers.

Characteristics of Included Studies

The study design characteristics of the 23 included studies that address Key Question 3A included 50 or more individuals (see Table 28). Additionally, none of the included studies specifically restricted the inclusion of drivers in their study populations by any of the key demographic variables examined.

Additional information about the studies, including location and scale of the studies (Table 27), risk of bias assessment (Table 29), and quality assessment (Table 30), can be found in the introduction of Key Question 3.

Findings

Twenty-three studies met our inclusion criteria for Key Question 3A. Overall, 20 of the 23 studies included truck drivers, two included bus drivers, and one included both truck and coach drivers. BLS data is provided for truck and motorcoach/bus drivers from 2002 to 2011, the most current year on record.

Gender

The gender distribution of truck and motorcoach/bus drivers was assessed using data from 13 truck driver studies, one bus driver study and one study that included both truck and coach drivers (see Table 31). Data from the BLS is also provided for comparative purposes.

Truck Drivers

Bureau of Labor Statistics Data

Among truck drivers in the past 10 years, the percent of male drivers ranged between 94.7 and 95.5 among an average of 3.28 million drivers in the BLS data[53]. The mean percent of male truck drivers was 95.12. The percent of female drivers ranged from 4.5 to 5.3, and the mean was 4.88 percent (refer to Appendix H).

Study Data

In 14 studies conducted between 2002 and 2012 (see Table 32), the percent of male truck drivers ranged between 86.3 and 99 among a total of 22,655 driver participants.

The percent of female drivers ranged from 1 to 13.7. The mean percent of male and female drivers was 95.5 and 4.5, respectively.

Table 32. Study Findings for Gender in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Gender Findings			
				Males		Females	
				N =	%	N =	%
Blanco et al.[114]	2011	96	Long distance	91	94.8	5	5.2
Crum et al.[119]*	2002	502	Long distance	NR	89	NR	11
		279	Long distance	NR	96	NR	4
Dinges & Maislin[80]	2006	2,280	Long distance, regional	2,230	97.8	50	2.2
Fine et al.[122]	2012	50	Long distance	49	98	1	2
Kashima[128]	2003	109	All types	107	98	2	2
McCartt et al.[132]	2008	354	Long distance	350	99	4	1
		338	Long distance	318	94	20	6

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Gender Findings			
				Males		Females	
				N =	%	N =	%
		356	Long distance	342	96	14	4
		350	Long distance	336	96	14	4
		236	Long distance	231	98	5	2
		287	Long distance	267	93	20	7
Morrow & Crum[45]	2004	116	All types	111	96	5	4
Rodriguez et al.[136]	2006	2,368	Long distance	2,311	97.6	57	2.4
Rodriguez et al.[137]	2003	11,540	Long distance	11,078	96	462	4
Smith & Phillips[140]	2011	595	NR	546	91.8	49	8.2
Solomon et al.[141]	2004	517	Local	481	93	36	7
Turner & Reed[143]	2011	300	Long distance	259	86.3	41	13.7
Whitfield Jacobson et al.[145]	2007	92	Long distance	87	94.6	5	5.4
Xie et al.[147]	2011	1,890	NR	1,731	91.6	159	8.4
Total (Mean)		**22,655**	**--**	**21,640**	**(95.5)**	**1,015**	**(4.5)**

NR – Not reported
* Study did not provide number of participants who responded to attribute, only the percentage of participants. For the purpose of drawing an overall mean of all studies, a number was configured based off the percentage and total number of participants.

Bus drivers

Bureau of Labor Statistics Data

Among bus drivers in the past 10 years, the percent of male drivers ranged from 48.4 to 56.4 among an average of 592,900 drivers in the BLS data[53]. The mean percent of males was 51.3. The percent of female drivers ranged from 43.4 to 51.6, with a mean of 48.7 percent (refer to Appendix H).

Study Data

Among one coach driver study (Crum et al., 2002[119]) and two bus driver studies (Escoto and French, 2012[121]; and Howarth, 2002[126]) that presented gender characteristics of motorcoach/bus driver participants, the percent of male drivers ranged between 75.5 and 88 among a total of 1,002 driver participants, as shown in Table 33. The percent of female drivers ranged from 12 to 24.5. The weighted mean percent of male and female drivers was 77.84 and 22.16, respectively.

Table 33. Study Findings for Gender in Motorcoach/bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local, Regional)	Gender Findings			
				Males		Females	
				N =	%	N =	%
Crum et al.[8]*	2002	122	Long distance	NR	88	NR	12
Escoto & French[121]	2012	779	Local	588	75.5	191	24.5
Howarth[126]	2002	101	Local	85	84.2	16	15.8

Study	Year	Number of Drivers	Types of Driving (Long distance, Local, Regional)	Gender Findings			
				Males		Females	
				N =	%	N =	%
Total (Mean)		**1,002**	**--**	**780**	**77.8**	**222**	**(22.2)**

NR – Not reported
* Study did not provide number of participants who responded to attribute, only the percentage of participants. For the purpose of drawing an overall mean of the studies' data, a number was configured based off the percentage and total number of participants.

The difference between the BLS data[53] and the three included studies is likely due to a lack of studies for motorcoach/bus drivers and the types of driver participants included in each dataset. Additionally, the BLS data include all types of bus drivers, such as school and special client drivers, whereas the three included studies assessed long-distance drivers employed at motorcoach firms (Crum et al., 2002[119]), local bus operators from four transit garages in a Midwestern city (Escoto and French, 2012[121]), and operators at a state-funded agency in the Northwest U.S. (Howarth, 2002[126]).

Truck and Motorcoach/bus Driver Comparison on Gender

Data retrieved from 16 included studies suggest (see Table 34):

- The majority of truck and motorcoach/bus drivers are male; and
- The percentage of women who drive motorcoach/bus (22.2 percent based on three studies) appears to be higher than women who drive trucks (4.5 percent).

While more females appear to drive motorcoach/bus, the estimated range is broad (12 to 24.5 percent), according to data obtained from the three studies. A more precise estimate is not possible with the data available.

Table 34. Comparison of Gender Among Truck and Coach Drivers

Population	No. of Studies	Total No. of participants	Studies Data (2002-2012)			
			Range %		Average %	
			Males	Females	Males	Females
Truck drivers	14	22,655	86.3 to 99	1 to 13.7	95.5	4.5
Coach drivers	3	1,002	75.5 to 88	12 to 24.5	77.8	22.2

Race/Ethnicity

The prevalence of race and ethnicity was assessed using data from nine truck driver studies, and one bus study (see Table 31). In this section, we consider race/ethnicity as white, black, Asian and other races, and identify Hispanic from non-Hispanic as a separate ethnicity category. Data from the BLS is also provided for comparative purposes.

Truck Drivers

Bureau of Labor Statistics Data

Among truck drivers in the past 10 years, BLS data[53] show that percentage of race/ethnicity groups ranged as follows (refer to Appendix H):

- **White:** 82.2 to 83.4 percent
- **Black:** 12.8 to 14.5 percent
- **Asian:** 1.1 to 1.9 percent
- **Other:** 1.1 to 2.3 percent
- **Non-Hispanic:** 81.3 to 86.1 percent
- **Hispanic:** 13.9 to 18.7 percent

The mean percentage of race/ethnicity groups among truck drivers during the past 10 years was:

- **White:** 82.77 percent
- **Black:** 13.71 percent
- **Asian:** 1.46 percent
- **Other:** 1.98 percent
- **Non-Hispanic:** 83.41 percent
- **Hispanic:** 16.59 percent

Study Data

In nine truck driver studies conducted between 2003 and 2012 (see Table 35), the prevalence of race/ethnicity groups among truck drivers ranged as follows:

- **White:** 56 to 95 percent
- **Black:** 3 to 36 percent
- **Asian:** 0.30 to 1.50 percent
- **Other:** 2.1 to 9.9 percent
- **Non-Hispanic:** 93 to 97.5 percent
- **Hispanic:** 2.5 to 7.0 percent

The overall average of race/ethnicity groups among truck drivers between 2003 and 2012 was:

- **White:** 81.97 percent
- **Black:** 10.11 percent*[2]
- **Asian:** 1.15 percent*
- **Other:** 3.83 percent*
- **Non-Hispanic:** 94.21 percent*
- **Hispanic:** 5.79 percent*

Table 35 shows the studies' prevalence of race/ethnic groups among truck drivers between 2003 and 2011.

[2] * Not all studies provide data for race/ethnicities; thus, the overall mean is derived from only studies that provide data.

Table 35. Study Findings for Race/Ethnicity in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Race/Ethnicity Findings									
				White		Black		Asian		Other		Hispanic	
				N=	%	N=	%	N=	%	N=	%	N=	%
Dinges & Maislin[80]	2006	2,126	Long distance, regional	1,918	90.2	132	6.2	31	1.5	45	2.1	113	5.5
Fine et al.[122]	2012	50	Long distance	28	56.0	18	36.0	NR	NR	NR	NR	3	6.0
Laden et al.[129]	2007	36,299	All types	30,668	84.5	3,359	9.3	NR	NR	NR	NR	NR	NR
Martin et al.[131]	2009	2,950	All types	2,035	69.0	708	24.0	NR	NR	NR	NR	207	7.0
Reed & Cronin[134]	2003	284	Long distance	270	95.0	NR	NR	NR	NR	NR	NR	NR	NR
Rodriguez et al.[136]	2006	2,368	Long distance	1,733	73.2	NR	NR	NR	NR	NR	NR	NR	NR
Rodriguez et al.[137]	2003	11,540	Long distance	8,920	77.3	NR	NR	NR	NR	NR	NR	NR	NR
Solomon et al.[141]	2004	517	Long distance	420	81.2	44	8.5	2	0.40	51	9.9	13	2.5
Turner & Reed[143]	2011	300	Long distance	265	88.3	9	3.0	1	0.30	17	6.4	8	3.0
Total (Mean)		**56,434**	**--**	**46,257**	**(81.97)**	**4,270**	**(10.11β)**	**34**	**(1.15β)**	**113**	**3.83β**	**344**	**5.79β**

NR – Not reported
β – Adjusted for missing data

Motorcoach/bus Drivers

Bureau of Labor Statistics Data

Among motorcoach/bus drivers in the past 10 years, BLS data[53] show the percent of race/ethnicity groups to range as follows (refer to Appendix H):

- **White:** 65.4 to 72.9 percent
- **Black:** 23.2 to 30.4 percent
- **Asian:** 1.2 to 2.2 percent
- **Other:** 0.08 to 2.8 percent
- **Non-Hispanic:** 86.7 to 89.8 percent
- **Hispanic:** 10.2 to 13.3 percent

The mean percent of race/ethnicity groups among drivers during the past 10 years is:

- **White:** 69.45 percent
- **Black:** 26.59 percent
- **Asian:** 1.68 percent
- **Other:** 2.28 percent
- **Non-Hispanic:** 87.96 percent
- **Hispanic:** 12.04 percent

Study Data

Only one study, Escoto and French (2012)[121], provided race/ethnicity data for local bus operators from four transit garages in a Midwestern city. In this study, 459 of the 779 drivers were white (59 percent) and 320 were non-white (41 percent). Escoto and French's estimate of white bus drivers falls outside the range of white bus drivers reported in the BLS data (65.4 to 72.9 percent). This difference might be explained by geographical differences in racial diversity for the single study compared to the population level data of the BLS. Additionally, the BLS data reflects a broader group of bus drivers (eg, school and special client bus drivers).

Truck and Motorcoach/bus Driver Comparison on Race/Ethnicity

Summary data regarding race and ethnicity of motorcoach/bus and truck drivers from 10 included studies are shown in Table 36. Based on available data from eight studies the mean percent of white truck drivers is approximately 82 percent.

Because of a lack of data for motorcoach/bus drivers, we are unable to provide an estimate on the racial and ethnic distribution for this driver group. Data from one study of transit bus drivers in a Midwestern U.S. city, with limited generalizability across different geographical locations, suggests that white individuals may comprise a smaller percentage of bus drivers than that of truck drivers; however, limited data preclude a conclusion on this demographic attribute.

Table 36. Prevalence of Race/Ethnicity Groups Among Truck and Motorcoach/bus Drivers

Population	No. of Studies	Total No. of participants	Race/Ethnicity Findings				
			Studies' Range % (Weighted Average %)				
			White	Black	Asian	Other	Hispanic
Truck drivers	9	56,434	56 to 95 (81.97)	3 to 36 (10.11)	0.30 to 1.5 (1.15)	2.1 to 9.9 (3.83)	2.5 to 7.0 (5.79)
Bus drivers	1	779	56	NR	NR	NR	NR

Age

The prevalence of age was assessed using 17 truck driver studies, two bus studies, and one study that addresses both truck and coach drivers (see Table 31). Data from the BLS is also provided for comparative purposes. In addition, data from the BLS is represented as the median age along with distribution across seven age groups. In the studies we examined, we present mean age among truck driver populations.

Truck Drivers

Bureau of Labor Statistics

Among truck drivers over the 10 year period of 2002-2011, BLS data [53] shows the range of median age and the percent of drivers in seven age groups as follows (refer to Appendix H):

- **Median Age:** 42.2 to 48.7
- **16 to 19 years:** 1.2 to 2.4 percent
- **20 to 24 years:** 5.5 to 7.1 percent
- **25 to 34 years:** 17.3 to 22.7 percent
- **35 to 44 years:** 23.4 to 28.2 percent
- **45 to 54 years:** 23.4 to 28.4 percent
- **55 to 64 years:** 12.3 to 17.9 percent
- **≥ 65 years:** 3.8 to 5.8 percent

The average median age and average prevalence of drivers in the seven age groups are as follows:

- **Median Age:** 44.3
- **16 to 19 years:** 1.60
- **20 to 24 years:** 6.24
- **25 to 34 years:** 19.92
- **35 to 44 years:** 26.68
- **45 to 54 years:** 25.94
- **55 to 64 years:** 14.97
- **≥ 65 years:** 4.62

Study Data

Among 16 truck driver studies conducted between 2002 and 2012 (see Table 37) and representing 62,115 drivers, the mean age among drivers ranged between 39.7 and 56.3 years. The weighted mean age was 43.70 years, with standard deviations ranging from 8.5 to 11.5 years across studies.

Table 37. Average Age of Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Average Age Findings		
				Mean Age	Range	SD of Years
Beilock[113]	2003	1,624	Long distance	44	NR	NR
Blanco et al.[114]	2011	96	Long distance	44	21 to 73	NR
Crum et al.[119]	2002	502	Long distance	41	21 to 72	NR
		279	Long distance	43	22 to 65	NR
Dinges & Maislin[80]	2006	2,188	Long distance, regional	52.6	NR	NR
Fine et al.[122]	2012	50	Long distance	40.5	NR	NR
Jain et al.[127]	2006	1,130	Long distance	56.3	NR	±8.5
		362	Local	53	NR	±9
Laden et al.[129]	2007	36,299	All types	44	NR	±9.1
Layne et al.[130]	2009	50	Long distance	48.5	NR	NR
Martin et al.[131]	2009	2,950	All types	45.2	NR	±10.2
Morrow & Crum[45]	2004	116	All types	43	23 to 63	NR
Reed & Cronin[134]	2003	284	Long distance	46	22 to 68	±9
Rodriguez et al.[136]	2006	2,368	Long distance	40.7	20 to 70	±9.5
Rodriguez et al.[137]	2003	11,540	Long distance	39.7	20 to 76	±10.14
Turner & Reed[143]	2011	300	Long distance	47	24 to 71	±10.0
Whitfield Jacobsen et al.[145]	2007	87	Long distance	44.3	NR	±10.6
Xie et al.[147]	2011	1,890	NR	43.7	18 to 77	±11.52
Total (Weighted mean)		**62,115**	**--**	**(43.70)**	**18 to 77**	

NR – Not reported; SD – Standard deviation

Two additional studies (McCartt et al., 2008[132]; and Solomon et al. (2004)[141]) also presented data on the age distribution of long-haul truck drivers. They were not included in the summary data above because mean data and standard deviations were not provided; thus they could not be combined with the summary data in Table 43. However, both provide a detailed age distribution of participants in the study. McCartt et al. is shown in Table 38, and Solomon et al. is shown in Table 40. Both distributions of age are comparable to data from the BLS with the majority of drivers between the ages of 30 and 59 years.

Table 38. Age Distribution of Long-Haul Truck Drivers (McCartt et al., 2008)

Age Ranges	Age Distribution Findings													
	PA: 2003		PA: 2004		PA: 2005		OR: 2003		OR: 2004		OR: 2005		N = 1,921	
	N = 354	%*	N = 356	%*	N = 236	%	N = 338	%	N = 350	%*	N = 287	%	Total	Mean* %
21-29	18	5	25	7	17	7	37	11	32	9	20	7	**149**	**7.8**
30-39	78	22	78	22	52	22	74	22	70	20	43	15	**395**	**20.6**
40-49	127	36	110	31	80	34	112	33	116	35	109	38	**654**	**34.0**
50-59	99	28	100	28	68	29	91	27	85	24	78	27	**521**	**27.1**
60-75	35	10	39	11	19	8	24	7	46	13	37	13	**200**	**10.4**

Source: McCartt et al.(2008)[132]
*McCartt reported 99 or 101 percent in its data.

Table 39. Age Distribution of Long-Haul Truck Drivers (Solomon et al., 2004)

Age Ranges	Long-Haul Truck Drivers	
	N = 516	%
22-29	56	11
30-39	148	29
40-49	178	34
50-59	111	22
60-75	23	4

Source: Solomon et al. (2004)[141]

Bus Drivers

Bureau of Labor Statistics Data

Among bus drivers over the 10 year period of 2002-2011, BLS data[53] show the range of median age and distribution of drivers in seven age groups as follows (refer to Appendix H):

- **Median Age:** 46 to 52.6
- **16 to 19 years:** 0.15 to 0.52 percent
- **20 to 24 years:** 0.87 to 3.4 percent
- **25 to 34 years:** 8 to 15.3 percent
- **35 to 44 years:** 17.0 to 28.7 percent
- **45 to 54 years:** 26.2 to 32.4 percent
- **55 to 64 years:** 18.3 to 27.6 percent
- **≥ 65 years:** 7.4 to 16.0 percent

The average median age and distribution of drivers in the seven age groups are as follows:

- **Median Age:** 49.46
- **16 to 19 years:** 0.20 percent
- **20 to 24 years:** 2.06 percent
- **25 to 34 years:** 11.28 percent

- **35 to 44 years:** 23.64 percent
- **45 to 54 years:** 28.94 percent
- **55 to 64 years:** 22.87 percent
- **≥ 65 years:** 10.99 percent

Study Data

Among one coach driver study (Crum et al., 2002[119]) and two bus driver studies (Escoto and French, 2012[121]; and Howarth, 2002[126]), the weighted mean age among 1,002 motorcoach/bus drivers was 48 and ranged between 47.4 and 53 years. The lower and upper ages included in these studies were 27 and 68 years, respectively. Drivers from these studies reflected both long distance coach drivers from across the nation (Crum et al., 2002[119]) and regional transit bus drivers from a Midwestern city (Escoto and French, 2012[121]) and from the Northeast (Howarth, 2002[126]).

Table 40 shows the average age among motorcoach/bus drivers in the three studies mentioned above.

Table 40. Average Age in Motorcoach/bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local, Regional)	Average Age Findings		
				Average Age	Range	SD of Years
Crum et al.[119]	2002	122	Long distance	53	28 to 68	NR
Escoto & French[121]	2012	778	Local	47.4	NR	10.5
Howarth[126]	2002	102	Local	46.5	27 to 66	NR
Total (Weight mean)		**1,002**	**--**	**(48*)**	**27 to 68**	**10.5**

NR – Not reported; SD – Standard deviation

Truck and Motorcoach/bus Driver Comparison on Age

Summary data from 18 included studies are presented in Table 41. Based on data from 16 studies, the weighted mean age of truck drivers was 43.7 years. Data from three studies of motorcoach/bus drivers suggest that the average age of such drivers is slightly older at 48 years. This is consistent with estimates from the BLS for the more broadly defined groups of bus and truck drivers[3] with median ages of 44.3 and 49.46 years over the period of 2002-2011, respectively. Although not available from the examination of study data, BLS data also suggest that the median age of bus and truck drivers is rising. In 2011, according to the BLS:

[3] For BLS data:

- **Bus Drivers** encompasses the following two occupations: 53-3021 Bus Drivers, Transit and Intercity (which includes coach drivers), and 53-3022 Bus Drivers, School or Special Client. Note: Data for coach drivers could not be isolated.
- **Driver/Sales Workers and Truck Drivers** encompasses the following three occupations: 53-3031 Driver/Sales Workers, 53-3032 Heavy and Tractor-Trailer Truck Drivers, and 53-3033 Light Truck or Delivery Services Drivers. Note: Data for heavy and tractor-trailer truck drivers could not be isolated.

- 51.7 percent of **truck drivers** were 45 years or older, as opposed to 39.8 percent in 2002. Every year, the number of older drivers has steadily increased.
- 73.4 percent of **bus drivers** were 45 years or older. This percentage has remained steady, although the 10-year average of this age group is 10 percent lower. This could be due to the growing number of motorcoach/bus drivers 65 years or older. This age group has steadily risen from 7.4 percent in 2002 to 16 percent in 2011.

Refer to Appendix H for additional information about age trends from the BLS.

Table 41. Prevalence of Age Among Truck and Motorcoach/bus Drivers

			Age Findings	
			Studies Data	BLS Data
Population	No. of Studies	No. of participants	Mean Age*	Mean of Median Age
Truck drivers	16	62,115	43.7	44.3
Coach drivers	3	1,002	48	49.46

* Weighted mean

Education

The distribution of driver education level was assessed using data from the BLS (2002 to 2011), three truck driver studies and one bus driver study (see Table 31). In this section, we relied primarily on data from the BLS given the lack of data from independent studies for motorcoach/bus and truck drivers. Additionally, the BLS provides a more comprehensive distribution of education categories (ie, five groups) over a 10-year time span. Because of different educational categories, we were not able to combine data for the individual studies into single summary table as we have for other attributes.

Truck Drivers

Bureau of Labor Statistics

Among truck drivers over the past 10 years, the BLS data[53] shows the distribution of drivers' education level as follows:

- **Less than high school diploma:** 15.0 to 20.5
- **High school diploma, no college:** 52 to 54 percent
- **Some college:** 16.3 to 18.9 percent
- **Associate degree:** 5.3 to 7.6 percent
- **Bachelor's degree:** 3.7 to 5.3 percent
- **Master's degree or higher:** 0.39 to 1.23 percent

The mean percentage of drivers in six education groups is as follows:

- **Less than high school diploma:** 17.8 percent

- **High school diploma, no college:** 53 percent
- **Some college:** 17.4 percent
- **Associate degree:** 6.2 percent
- **Bachelor's degree:** 4.9 percent
- **Master's degree or higher:** 0.8 percent

Study Data

Among truck drivers in the past 10 years, three included studies (Blanco et al., 2011[114]; Fine et al., 2012[122]; and Layne et al., 2009[130]) report on education levels of drivers. Based on these studies, the range of drivers' education is as follows:

- **Less than high school diploma:** 8.0 to 14.0 percent
- **High school diploma:** 36.8 to 42.7 percent
- **Some college:** 32.3 to 48 percent
- **College or higher:** 2 to 50 percent

The weighted mean percentage of drivers in each of these four education groups is as follows:

- **Less than high school diploma:** 10.20 percent
- **High school diploma:** 40.8 percent
- **Some college:** 37.7 percent
- **College or higher:** 20.9 percent

Table 42 shows the studies' prevalence of education among truck drivers, on average, between 2009 and 2011.

Table 42. Findings for Education Level of Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Education Findings							
				Less Than High School Diploma		H.S. Diploma		Some College		College or Higher[1]	
				N	%	N	%	N	%	N	%
Blanco et al.[114]	2011	96	Long distance	9	9.4	41	42.7	31	32.3	15	15.6
Fine et al.[122]	2012	50	Long distance	7	14.0	18	36.0	24	48.0	1	2.0
Layne et al.[130]	2009	50	Long distance	4	8.0	21	42.0	NR	NR	25	50.0
Total (Mean)		**196**	**--**	**20**	**(10.20)**	**80**	**(40.8)**	**55**	**(37.7[β])**	**41**	**(20.9)**

NR – Not reported
1 Includes two-year degrees
β Adjusted for missing data

An additional study also presents data on the highest level of education completed among a group of long-haul truck drivers (Solomon et al. (2004)[141]). The investigators of this study collected demographic data and information about access to health-care services in a survey administered to 521 drivers nationwide. It was not included in the summary data above because mean data and standard deviations were not provided; thus it could not be combined with the summary data in Table 42. However, it provides a detailed distribution of the level of education completed for participants in the study. This data is shown in Table 43. The numbers are somewhat comparable to those of the summary data presented above. Of the 515 drivers who responded, 34 percent had finished high school or received a high school equivalency diploma (GED) compared to approximately 40.8 percent in the other three truck driver studies. Approximately 35 percent had either some trade school or some college compared with 37.7 percent of individuals on average in the other studies.

Table 43. Highest Education Level of Long-Distance Truck Drivers (Solomon et al. 2004)

Level of Education	Long-Distance Truck Drivers	
	N = 515	%
Some high school	38	7
GED	46	9
Finished high school	127	25
Some trade school	29	6
Trade school degree	48	9
Some college	150	29
College degree	56	11
Some graduate or professional	12	2
Graduate or professional degree	9	2

GED – General Educational Diploma
Source: Solomon et al. (2004)[141]

Bus Drivers

Bureau of Labor Statistics Data

Among bus drivers over the past 10 years, the BLS data[53] shows the distribution of driver education level as follows:

- **Less than high school diploma:** 7.0 to 14.0 percent
- **High school diploma, no college:** 48.8 to 53.2 percent
- **Some college:** 20.7 to 24.4 percent
- **Associate degree:** 6.8 to 9.4 percent
- **Bachelor's degree:** 5.0 to 8.3 percent
- **Master's degree or higher:** 1.1 to 2.0 percent

The average percent of drivers in five education groups is as follows:

- **Less than high school diploma:** 10.6 percent
- **High school diploma, no college:** 50.7 percent
- **Some college:** 22.4 percent
- **Associate degree:** 8.3 percent

- **Bachelor's degree:** 6.5 percent
- **Master's degree or higher:** 1.5 percent

Study Data

One included bus driver study (Escoto and French, 2012[121]) assessed the distribution of education levels among 773 transit bus drivers. The findings from this study are shown in Table 44.

Escoto and French's data is comparable to BLS data in that its percent of bus drivers who went "up to high school" was 45.8 percent, compared to the BLS' mean percent of 50.7 for those who received a high school diploma. Escoto and French do not provide the number of drivers who did not receive a high school diploma. The proportion of bus drivers who graduated from a college program is 14.4 percent, compared to the BLS' combined total of 16.25 percent of drivers who had an associate degree or higher.

Table 44. Prevalence of Education in Motorcoach/bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local, Regional)	Education Findings					
				Up to High School		Some College		College or higher[1]	
				N	%	N	%	N	%
Escoto & French[121]	2012	773	Local	354	45.8	308	39.8	111	14.4
Total (Mean)		**773**	**--**	**354**	**(45.8)**	**308**	**(39.8)**	**111**	**(14.4)**

1 Includes associate degree

Truck and Motorcoach/bus Driver Comparison on Education

A paucity of literature for both truck and motorcoach/bus drivers regarding education levels limits our ability to arrive at conclusions about difference between these two driver groups with regard to educational backgrounds.

Summary data among the four included studies and BLS data are presented in Table 45. The conclusions about education level presented below are based on BLS data, which applies broader definitions for both truck and bus drivers as described earlier in this section, limiting the relevance to the specific driver groups targeted by this question.

- More truck drivers (17.8 percent) than motorcoach/bus drivers (10.6 percent), on average, do not have a high school diploma, although the number of all drivers who have a high school diploma has increased in recent years, according to BLS data from 2002-2011.
- Approximately 53 percent of truck drivers and 51 percent motorcoach/bus drivers have a high school diploma, but have not attended college.
- More motorcoach/bus drivers, on average, have some college or have received an associate degree or higher (38.7 percent) compared with truck drivers (29.3 percent), although the number of all drivers who have received some higher education or a degree has steadily increased over the period of 2002-2011.

Table 45. Prevalence of Education Among Truck and Motorcoach/bus Drivers

Population	No. of Studies	No. of Participants	Education Findings									
			Studies' Mean %				BLS Mean %					
			Less Than H.S. Diploma	H.S. Diploma	Some College	College or More	Less Than H.S. Diploma	H.S. Diploma	Some College	Associates Degree	Bachelor's Degree	Master's or Higher
Truck drivers	3	196	10.20	40.8	37.7	20.9	17.8	53	17.4	6.2	4.9	0.8
Bus drivers	1	773	NR	45.8	39.8	14.4	10.6	50.7	22.4	8.3	6.5	1.5

NR – Not reported

Income

Motorcoach/bus and truck driver income was assessed using data from the BLS Occupational Employment Statistics Query System (OES) and the National Compensation Survey, both of which provide mean hourly and annual income data. This data is supplemented with data from two truck driver studies and one bus driver study (see Table 31), which report the range of annual income of drivers. Unlike other demographic attributes reported from the BLS, data regarding income is derived from a different survey source, which reports occupational data at a more granular level. Income data is available for the following relevant occupational categories of drivers:

- 533021: Bus drivers, transit and intercity
- 533032: Truck drivers, heavy and tractor-trailer

In this section, data from the BLS include estimated mean hourly and annual wages for truck and motorcoach/bus drivers (excluding school bus and special client bus drivers), providing more specific and comparable data over a 10-year period when compared with other demographic attributes reported by the BLS. We also discuss the trends seen within the three included studies, which did not provide mean annual wages, but rather ranges of annual income.

Truck Drivers

Bureau of Labor Statistics

Among truck drivers over the past 10 years, BLS data[150] show (see Table 46):

Hourly Wage

- Truck drivers' mean hourly wage ranged from a low of $16.49 in 2003 to a high of $19.15 in 2011, an increase of $2.66 per hour over the 10 years. The mean hourly wage in five-year increments was $18.73 between 2007 and 2011 and $16.62 between 2002 and 2006, an increase of $1.81 over the most recent five-year period.

Annual Income

- Truck drivers' mean annual income ranged from a low of $34,290 in 2003 to a high of $39,830 in 2011, an increase of $5,540 over the 10 years. The mean annual wage in five-year increments was $38,964 between 2007 and 2011 and $35,068 between 2002 and 2006, an increase of $3,896 over the most recent five-year period.

Table 46 shows BLS data on drivers' income between 2002 and 2011.

Table 46. BLS Estimate of Wages for Truck Drivers, 2002-2011

BLS Income Findings					
Year	Mean Hourly Pay	Mean Annual Pay	Year	Mean Hourly Pay	Mean Annual Pay
2011	$19.15	$39,830	**2006**	$17.46	$36,320
2010	$18.97	$39,450	**2005**	$17.05	$35,460
2009	$18.87	$39,260	**2004**	$16.79	$34,920
2008	$18.62	$38,720	**2003**	$16.49	$34,290
2007	$18.05	$37,560	**2002**	$16.52	$34,350
Mean	**$18.73**	**$38,964**	**Mean**	**$16.62**	**$35,068**

Study Data

Only two truck driver studies met the inclusion criteria for this category.

Solomon et al. (2004)[141], which assessed 511 long-haul drivers' health in 2003, found that about 59 percent of drivers earned $55,000 or less (see Table 47). More than 41 percent earned more than $55,000.

Table 47. Income Earned Among Long-Haul Truck Drivers, 2003

Income	N = 511 (of 521) (%)
Less than $25,000	23 (5)
$25,000 to $35,000	86 (17)
$35,001 to $55,000	191 (37)
$55,001 to $75,000	106 (21)
$75,001 to $100,000	44 (9)
$100,001 or more	61 (12)

Source: Solomon et al, 2004[141]

Layne et al. (2009)[130], which focused on health and gender comparisons of 23 male and 24 female long-haul drivers, found a similar result to Solomon et al. with 55 percent of drivers earning $55,000 or less and 45 percent earning more than $55,000 (see Table 48). When considering gender, the study revealed that 33 percent of women earned $35,000 or less compared to only 4 percent of men.

Table 48. Income Earned Among Male and Female Long-Haul Truck Drivers, 2009

Income	Male N = 23 (%)	Female N = 24 (%)	Male and Female N = 47 (%)
$35,000 or less	1 (4)	8 (33)	9 (19)
$35,001 to $55,000	12 (53)	5 (21)	17 (36)
$55,001 to $75,000	4 (17)	4 (17)	8 (17)
$75,001 to $100,000	3 (13)	3 (12)	6 (13)
$100,001 or more	3 (13)	4 (17)	7 (15)

Source: Layne et al., 2009[130]

Motorcoach/bus Drivers

Bureau of Labor Statistics

Among motorcoach/bus drivers over the past 10 years, BLS data[150] show (see Table 46):

Hourly Wage

- Motorcoach/bus drivers' mean hourly wage ranged from a low of $14.77 in 2003 to a high of $18 in 2011, an increase of $3.23 per hour over the 10 years. The average hourly wage in five-year increments was $17.34 between 2007 and 2011 and $15.22 between 2002 and 2006, an increase of $2.12 over the most recent five-year period.

Annual Income

- Motorcoach/bus drivers' mean annual income ranged from a low of $30,730 in 2003 to a high of $37,440 in 2011, an increase of $6,710 over the 10 years. The average annual wage in five-year increments was $36,068 between 2007 and 2011 and $31,660 between 2002 and 2006, an increase of $4,408 over the most recent five-year period.

Table 49 shows BLS data on drivers' income between 2002 and 2011.

Table 49. BLS Estimate of Wages for Motorcoach/bus Drivers, 2002-2011

BLS Income Findings					
Year	Mean Hourly Pay	Mean Annual Pay	Year	Mean Hourly Pay	Mean Annual Pay
2011	$18.00	$37,440	**2006**	$15.89	$33,050
2010	$17.82	$37,060	**2005**	$15.37	$31,960
2009	$17.30	$35,990	**2004**	$15.27	$31,750
2008	$17.16	$35,700	**2003**	$14.77	$30,730
2007	$16.42	$34,150	**2002**	$14.81	$30,810
Mean	**$17.34**	**$36,068**	**Mean**	**$15.22**	**$31,660**

Study Data

Only one bus driver study, Escoto and French (2012)[121], met the inclusion criteria for this driver group. In its efforts to examine the prevalence of unhealthy and healthy weight controls used by bus drivers, Escoto and French found that 60 percent of its 766 participants (local transit bus operators in a Midwestern U.S. city) earned $50,000 or less.

Truck and Motorcoach/bus Driver Comparison on Income

Our analysis of income for truck and motorcoach/bus drivers is divided into two parts: BLS data and study data, because the three included studies did not provide mean estimates of annual income, but rather ranges. We were thus not able to make a direct comparison to data from the BLS.

Trends observed in the BLS data show (see Table 50):

- Truck drivers have consistently earned more than motorcoach/bus drivers by an average of at least $1 more per hour and $2,000 per year during the past 10 years.
- Motorcoach/bus drivers' income grew faster than truck drivers' income between 2002 and 2011.
  - Mean hourly wage increased by:
    - **$3.23** for motorcoach/bus drivers; and
    - **$2.66** for truck drivers.
  - Mean annual income increased by:
    - **$6,710** for motorcoach/bus drivers; and
    - **$5,540** for truck drivers.

Trends among the included studies show (see Table 51):

- Between 50 and 60 percent of truck and bus drivers make $55,000 or less. More specifically:
  - 55 to 59 percent of truck drivers earn $55,000 or less; and
  - 60 percent of motorcoach/bus drivers earn $50,000 or less.
- One in three female truck drivers earns $35,000 or less a year compared to only 4 percent of male truck drivers. Data for female motorcoach/bus drivers was not available.

Table 50. BLS Income Data for Truck and Motorcoach/bus Drivers

Wage Type	BLS Income Findings	
	Truck Drivers	Motorcoach/bus Drivers
10-Year Range		
Hourly Wage	$16.49 to $19.15	$14.77 to $18
Annual Income	$34,290 to $39,830	$30,730 to $37,440
10-Year Mean		
Hourly Wage	$17.97	$16.28
Annual Income	$37,016	$33,864

5-year Range (2007-2011)		
Hourly Wage	$18.05 to $19.15	$16.42 to $18
Annual Income	$37,560 to $39,830	$34,150 to $37,440
5-Year Mean (2007-2011)		
Hourly Wage	$18.73	$17.34
Annual Income	$38,964	$36,068
5-Year Range (2002-2006)		
Hourly Wage	$16.49 to $17.46	$14.81 to $15.89
Annual Income	$34,290 to $36,320	$30,730 to $33,050
5-Year Mean (2002-2006)		
Hourly Wage	$16.62	$15.22
Annual Income	$35,068	$31,660

Table 51. Income Among Truck and Motorcoach/bus Drivers

Income Level	Truck Drivers %	Income Level	Motorcoach/bus Drivers %
$35,000 or less	22	**$50,000 or less**	60
$35,001 to $55,000	37	**Greater than $50,000**	40
$55,001 to $75,000	20		
$75,001 to $100,000	9		
$100,001 or more	12		

Marital Status

Driver marital status was assessed with seven truck driver studies and one bus driver study (see Table 31), Note, BLS did not have data available for this demographic as it only provides marital status data by industry, not by occupation.

Truck Drivers

The findings of seven included studies (see Table 52) show drivers who were "married" ranged from 48 to 83 percent, with a mean of 55 percent. Despite the finding, the largest study (Rodriguez et al., 2006[136]) – comprising 11,540 participants, 69 percent of all participants among the seven studies – had conflicting data, finding that 48 percent of drivers were "married," 7 percent less than the mean of all studies.

Three studies (Fine et al., 2012[122]; Layne et al., 2009[130]; and Solomon et al., 2004[141]) reported the number of drivers who were "separated" or "divorced," showing that approximately 19 percent of drivers are divorced and 3 percent are separated, on average.

Only two studies, Layne et al. and Solomon et al., reported the number of drivers who were widowed, showing a mean of nearly 1 percent among drivers.

Table 52. Prevalence of Marital Status Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Marital Status Findings									
				Single[1]		Married		Divorced		Separated		Widowed	
				N=	%	N=	%	N=	%	N=	%	N=	%
Dinges & Maislin[80]	2006	1,997	Long distance, regional	344	17	1,653	83	NR	NR	NR	NR	NR	NR
Fine et al.[122]	2012	50	Long distance	14	28	36	72	3	6	2	4	NR	NR
Layne et al.[130]	2009	49	Long distance	20	41	29	59	10	20	4	8	0	0
Reed & Cronin[134]	2003	284	Long distance	62	22	222	78	NR	NR	NR	NR	NR	NR
Rodriguez et al.[136]	2006	2,368	Long distance	924	39	1,444	61	NR	NR	NR	NR	NR	NR
Rodriguez et al.[137]	2003	11,540	Long distance	6001	52	5,539	48	NR	NR	NR	NR	NR	NR
Solomon et al.[141]	2004	517	Long distance	219	43	298	57	102	20	14	3	5	1
Total (Mean)		**16,805**	**--**	**7,584**	**(45.13)**	**9,221**	**(54.87)**	**115**	**(18.67β)**	**20**	**(3.25 β)**	**5**	**(0.88β)**

NR – Not reported

1 Includes all persons not married, including divorced, separated and widowed
β – Adjusted for missing data

Motorcoach/bus Drivers

Study Data

Only one study (Howarth, 2002[126]) met the inclusion criteria for the marital status of motorcoach/bus drivers. In its efforts to investigate differences of self-reported sleep length and aspects of fatigue among 102 bus drivers, it found that 67 percent of drivers were married or cohabitating with a significant other. Thirty-three percent were single, divorced, separated, or widowed. More detailed groupings were not included.

Truck and Motorcoach/bus Driver Comparison on Marital Status

The data for our analysis of marital status regarding truck and bus drivers is not comparable, as the only bus study includes non-married people who cohabitate together, and the truck driver studies do not. Despite this, the data show that half or more of truck and bus drivers are married or live with a significant other. The paucity of data, however, makes it difficult to provide an accurate estimate on marital status.

Table 53. Marital Status Among Truck and Bus Drivers

Marital Status	Truck Drivers %	Bus Drivers %
Single	45	37
Married	55	67*
Divorced	19	NR
Separated	3	NR
Widowed	1	NR

NR – Not reported

* This percent includes married and individuals who cohabitate together.

Job Tenure

The prevalence of drivers' work experience was assessed with 10 truck driver studies, one coach driver study and one bus driver study (see Table 31). Note: BLS data for job tenure was not included in this section as the BLS only provides data at the industry level, not at the occupational level.

Truck Drivers

Ten truck driver studies (see Table 54) met the inclusion criteria for this category. The number of participants totaled 356,441 drivers, showing a weighted mean of 10.9 years of driving experience with means across studies ranging from 5.0 to 26.9 years.

Table 54. Prevalence of Job Tenure Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Job Tenure Findings		
				Mean Years	Range of Years	Stand Deviation
Beilock[113]	2003	1,600	Long distance	17.0	NR	NR
Blanco et al.[114]	2011	96	Long distance	9.1	4 weeks to 54 years	NR
Crum et al.[119]	2002	502	Long distance	11.7	NR	NR
		279	Long distance	15.8	NR	NR
Dinges & Maislin[80]	2006	2,203	Long distance, regional	26.9	NR	NR
Garshick et al.[124]	2002	60,634	Long distance	10.0	NR	8.5
		79,416	Long distance	8.8	NR	8.2
		88,185	Long distance	9.5	NR	7.9
		84,367	Long distance	10.6	NR	8.2
Laden et al.[129]	2007	36,299	All types	20.3	NR	8.1
Morrow & Crum[45]	2004	116	All types	14.9	NR	NR
Reed & Cronin[134]	2003	284	Long distance	8.3	NR	NR
Rodriguez et al.[136]	2006	2,368	Long distance	5.0	2 months to 37.8 years	4.6
Whitfield Jacobson et al.[145]	2007	92	Long distance	13.9	NR	12.51
Total (Weighted mean)		**356,441**	**--**	**(10.9)**	**4 weeks to 54 years**	**4.6 – 12.51**

NR – Not Reported

Motorcoach/bus Drivers

Study Data

One coach study (Crum et al., 2002[119]) and one bus driver study (Howarth, 2002[126]) met the inclusion criteria for job tenure for this driver group (see Table 55).

Crum et al., which assessed scheduling practices’ effects on driver fatigue among 122 motorcoach drivers, found the mean tenure to be 20 years, with driving experience ranging from one year to 40 years. Howarth, which assessed differences in self-reported sleep length and aspects of fatigue among 102 bus drivers, found the mean job tenure to be much less at 12 years and 2 months. The weighted mean job tenure between the two studies was 16.5 years.

Table 55. Prevalence of Job Tenure Among Motorcoach/bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Job Tenure Findings		
				Mean Years	Range of Years	Stand Deviation
Crum et al.[119]	2002	122	Long distance	20	NR	NR
Howarth[126]	2002	102	Local	12.2	NR	NR
Total (Weighted mean)		224	--	16.5	--	--

NR – Not Reported

Truck and Motorcoach/bus Driver Comparison on Job Tenure

The data for our analysis on job tenure reveals motorcoach/bus drivers have more driving experience than truck drivers; however, a paucity of data for motorcoach/bus drivers makes this finding an unreliable estimate (see Table 56). The truck driver studies found that its 356,441 participants had an average of 10.9 years of driving experience, and the motorcoach/bus studies found that its 224 participants had 16.5 years of driving experience, although coach drivers alone had a mean of 20 years.

Table 56. Mean Years of Driving Experience for Truck and Motorcoach/bus Drivers

Mean Years for Job Tenure	
Truck Drivers	**Motorcoach/bus Drivers**
10.6 years among 368,202 participants	16.6 years among 224 drivers

Section Summary for Key Question 3A

In this section we sought to characterize key demographic attributes of motorcoach/bus drivers and truck drivers, and more specifically, to identify any demographic traits for which there were differences between the two driver types. We examine seven demographic traits: gender, race/ethnicity, age, level of education, income, marital status, and job tenure. Data for this section derived from two primary sources: demographic data from the BLS for relevant occupational categories (bus and truck drivers), and demographic characteristics of drivers described in 23 studies of motorcoach/bus and/or truck drivers, conducted in the U.S. over the last 10 years. In general, there was a paucity of data available for motorcoach/bus drivers, limiting the conclusions that can be drawn about differences between truck and motorcoach/bus drivers. The key findings for each of the seven demographic attributes assessed are described below.

Gender

Data retrieved from the BLS and 16 included studies reveal:

- The majority of truck and motorcoach/bus drivers are male; and
- The percent of women who drive motorcoach/bus (22.2 percent based on only three studies) appears to be higher than women who drive trucks (4.5 percent).

While more females appear to drive motorcoach/bus, the estimated range is broad (12 to 24.5 percent), according to data obtained from only three motorcoach/bus studies. A more precise estimate is not possible with the data available.

Race/Ethnicity

Based on available data from nine studies, the mean percent of white truck drivers is approximately 82 percent.

Because of a lack of data for motorcoach/bus drivers, we are unable to provide an estimate on the racial and ethnic distribution this driver group. Data from one study of transit bus drivers in a Midwestern U.S. city, with limited generalizability across different geographical locations suggests that white individuals may comprise a smaller percentage of bus drivers than truck drivers; however, limited data preclude a conclusion on this demographic attribute.

Age

Based on data from 20 studies, the weighted mean age of truck drivers was 43.7 years. Data from three studies suggest the average age of motorcoach/bus drivers is slightly older at 48 years. This is consistent with estimates from the BLS for the more broadly defined groups of bus and truck drivers with median ages of 44.3 and 49.46 years over the period of 2002-2011, respectively. Although not available from the examination of included studies, BLS data also suggest that the median age of bus and truck drivers is increasing. In 2011, according to the BLS:

- 51.7 percent of **truck drivers** were 45 years or older, as opposed to 39.8 percent in 2002. Every year, the number of older drivers has steadily increased.
- 73.4 percent of **bus drivers** were 45 years or older. This percent has remained steady, although the 10-year average of this age group is 10 percent lower. This could be due to the growing number of motorcoach/bus drivers 65 years or older. This age group has steadily risen from 7.4 percent in 2002 to 16 percent in 2011.

Education

A paucity of literature for both truck and motorcoach/bus drivers regarding level of education achieved limits our ability to arrive at conclusions about differences between these two driver groups with regard to educational background.

Conclusions about education level presented below are based on BLS data, which applies broader definitions for both truck and bus drivers as described earlier in this report, limiting the relevance to the specific driver groups targeted by this question.

- More truck drivers (17.8 percent) than motorcoach/bus drivers (10.6 percent), on average, do not have a high school diploma; although the number of all drivers who have a high school diploma has increased in recent years, according to BLS data from 2002-2011.
- Approximately 53 percent of truck drivers and 51 percent motorcoach/bus drivers have a high school diploma, but have not attended college.

- More motorcoach/bus drivers, on average, have some college or have received an associate degree or higher (38.7 percent) compared with truck drivers (29.3 percent); although the number of all drivers who have received some higher education or a degree has steadily increased over the period of 2002-2011.

Income

Data retrieved from the BLS Occupational Employment Statistics Query System (OES) and the National Compensation Survey, both of which provide data specific to the driver types[4] targeted by this key question, reveals:

- Truck drivers have consistently earned more than motorcoach/bus drivers by an average of at least $1 more per hour and $2,000 per year during the past 10 years.
- Motorcoach/bus drivers' income grew faster than truck drivers' income between 2002 and 2011.
  - Mean hourly wage increased by:
    - **$3.23** for motorcoach/bus drivers; and
    - **$2.66** for truck drivers.
  - Mean annual income increased by:
    - **$6,710** for motorcoach/bus drivers; and
    - **$5,540** for truck drivers.

Data retrieved from the three included studies show:

- Between 50 and 60 percent of truck and bus drivers make $55,000 or less. More specifically:
  - 55 to 59 percent of truck drivers earn $55,000 or less; and
  - 60 percent of bus drivers earn $50,000 or less.
- One in three female truck drivers earns $35,000 or less a year compared to only 4 percent of male truck drivers. Data for female motorcoach/bus drivers was not available.

Marital Status

Data retrieved from eight included studies reveal:

- Half or more of truck and bus drivers are married or living with a significant other. The paucity of data, however, makes it difficult to provide an accurate estimate on marital status.

Job Tenure

Data retrieved from 12 included studies reveal (Table 54):

- Motorcoach/bus drivers have more experience in terms of job tenure than truck drivers.

[4] 533021: Bus drivers, transit and intercity; 533032: Truck drivers, heavy and tractor-trailor

- The truck driver studies found that its 356,441 participants had an average of 10.9 years driving experience.
- The motorcoach/bus studies found that its 224 participants had 16.5 years driving experience, although coach drivers alone had 20 years.

Key Question 3B: Job Function

In this section, we assessed the job function of heavy and tractor-trailer truck drivers and motorcoach/bus drivers, and compare similarities and differences between the two groups.

Heavy and tractor-trailer truck drivers, as defined by the BLS[151], transport goods from one location to another, and most are long-haul operators, operating from trucks with a capacity of 26,001 pounds gross vehicle weight. They deliver goods over intercity routes, sometimes spanning several states.

Bus drivers, as defined by the BLS[152], consist of four types of drivers:

1. *Local transit bus drivers* follow a daily schedule while transporting people on regular routes along the same city or suburban streets.

2. *Intercity bus drivers* transport passengers between cities or towns, sometimes crossing state lines. They may travel between distant cities or between towns only a few miles apart. They usually pick up and drop off passengers at bus stations, where passengers buy tickets. Increasingly, intercity buses are using curbside locations in downtown urban areas instead of stations.

3. *Motorcoach drivers* transport passengers on chartered trips or sightseeing tours. Their schedule and routes are generally arranged by a trip planner for the convenience of the passengers, who often are on vacation. The drivers are usually away for long periods of time because they usually stay with vacationers for the length of the trip.

4. *School bus drivers* transport students to and from school and to field trips, sporting events, and other activities. Some drivers work at school in other occupations, such as janitors, cafeteria workers, or mechanics, between morning and afternoon trips.

For the purpose of this report, we focus on motorcoach and bus drivers (excluding school bus) as they drive longer distances, similar to truck drivers.

Box 2 identifies the job functions of driver groups we are assessing.

Box 2. Typical Job Functions of Truck and Motorcoach/bus Drivers

Heavy and Tractor-Trailer Truck Drivers	Bus Drivers	
	Intercity Bus Drivers	Motor coach drivers
• Load and unload cargo • Drive long distances • Report to a dispatcher any incidents	• Ensure all passengers have a valid ticket to ride the bus • May sell tickets to passengers when	• Listen to and address passenger complaints • Drive long distances

encountered on the road • Follow all applicable traffic laws • Inspect their trailer before and after the trip, and record any defects they find • Keep a log of their activities • Report serious mechanical problems to the appropriate personnel • Keep their truck, and associated equipment, clean and in good working order	there are unsold seats available • Follow a central dispatcher's instruction when taking an alternate route • Help passengers load or unload baggage • Keep a log of their activities • Report serious mechanical problems to the appropriate personnel • Keep their bus, and associated equipment, clean and in good working order	• Load and unload baggage/cargo • Ensure the tour stays on schedule • Follow all applicable traffic laws • Sometimes act as tour guides for passengers • Help passengers load or unload baggage • Account for all passengers before leaving a location • Keep a log of their activities • Report serious mechanical problems to the appropriate personnel • Keep their bus, and associated equipment, clean and in good working order

Source: Bureau of Labor Statistics

To identify similarities and differences of job function between truck and motorcoach/bus drivers, we evaluated the following:

- Roads travelled
- Distance travelled
- Driving time
- Total time worked
- Loading requirements
- Light duties
- Pre-trip operations
- Opportunities for rest

Identification of Evidence Base

Database search strategies for Key Question 3B are provided in Appendix A. Our searches identified a total of 226 articles that appeared to be relevant to this key question. Following application of the retrieval criteria for this question (refer to Appendix B), 36 full-length articles were retrieved and read in full, and 16 articles were determined to meet our inclusion criteria (refer to Appendix C). Table D-1 of Appendix D lists the 20 articles that were excluded along with the rationale for their exclusion.

The study selection process for Key Question 3B is illustrated in Figure 8.

Figure 8. Development of Evidence Base for Key Question 3B

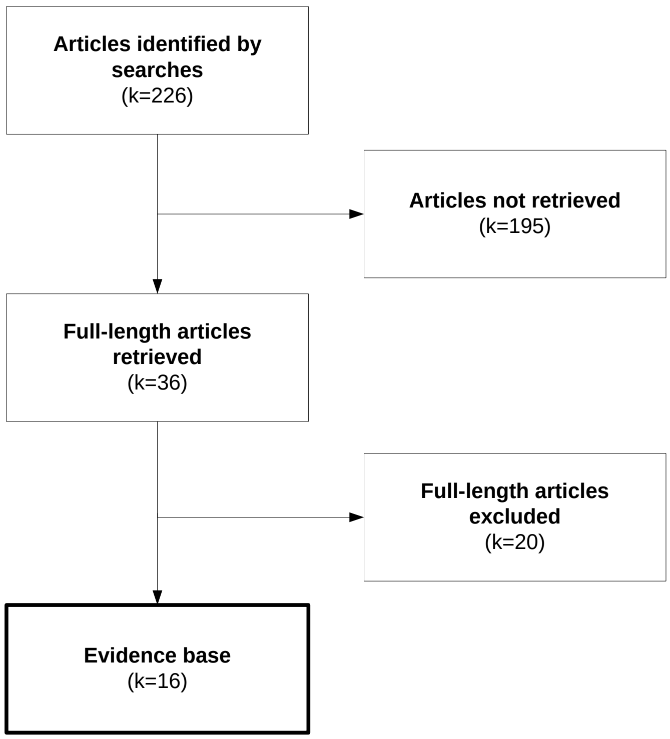


Table 57 identifies the included studies utilized in one or more of the eight job function attributes assessed. Studies listed in this table are further segmented by driver (eg, truck drivers or motorcoach/bus drivers).

Table 57. Methods for Assessing Job Function Characteristics Key Question 3B

		Job Function Characteristics Reported							
Reference	**Year**	**Roads Travelled**	**Distance Travelled**	**Driving Time**	**Total Time Worked**	**Loading Requirements**	**Light duties**	**Pre-Trip Operations**	**Opportunities for Rest**
Commercial Motor Vehicle Drivers – Truck									
Beilock[113]	2003		✓						
Blanco et al.[114]	2011			✓		✓	✓		
Crum et al.[119]*	2002		✓						✓
Dinges & Maislin[80]	2006					✓		✓	✓
Fine et al.[122]	2012	✓	✓						
Layne et al.[130]	2009			✓					

		Job Function Characteristics Reported							
Reference	Year	Roads Travelled	Distance Travelled	Driving Time	Total Time Worked	Loading Requirements	Light duties	Pre-Trip Operations	Opportunities for Rest
McCartt et al.[132]	2008			✓	✓				✓
Morrow & Crum[45]	2004		✓						✓
Reed & Cronin[134]	2003			✓					
Rodriguez et al.[136]	2006		✓						
Rodriguez et al.[137]	2003		✓						
Solomon et al.[141]	2004				✓				
Stasko & Neale[142]	2007			✓	✓				
Commercial Motor Vehicle Drivers – Motorcoach/bus									
Crum et al.[119]*	2002		✓		✓				
Escoto and French	2012				✓				
Howarth[126]	2002	✓			✓				✓
Sando et al.[138]	2010			✓	✓				✓
Total		**2**	**7***	**6**	**7**	**2**	**1**	**1**	**6**

*Crum et al., 2002, a single article, assessed both truck and coach drivers, and therefore, the total number of studies for an attribute may look like it's one number more than it should be.

Evidence Base Description

Characteristics of Included Studies

The primary characteristics of the 16 included studies that address Key Question 3B are presented in Table 28, at the beginning of this section. Two primary study designs (cross-sectional and cohort) characterize the studies included in the evidence base for this key question. Although the included studies assess various topics, their commonality is that they provide data on one or more of the nine categories that distinguish job function trends among truck and motorcoach/bus drivers.

Additional information about the studies, including location and scale of the studies (Table 27), risk of bias assessment (Table 29), and quality assessment (Table 30), can be found in the introduction of Key Question 3.

Findings

Fourteen studies met our inclusion criteria for Key Question 3B, which assessed job functions of truck and motorcoach/bus drivers. Overall, 12 studies focused on truck drivers, three on bus drivers, and one addressed both truck and coach drivers.

Roads Travelled

Two included studies (Fine et al., 2012[122]; and Howarth, 2002[126]) met the inclusion criteria for types of roads travelled by drivers. Fine et al. surveyed long-haul truck drivers from Alabama-based trucking companies. The Howarth study surveyed transit bus operators who worked at a state-funded agency in the Northeast (see Table 57).

Truck Drivers

Fine et al., which investigated the interaction of the cognitive and technological aspects of distracted driving and physical health among 50 truck drivers, asked participants to classify the types of roads they most often travelled on. Available options were:

- Interstate
- Local
- Highway
- Rural

Forty-nine (98 percent) participating drivers reported spending most of their driving time on the interstate, while one driver reported driving primarily on highways (see Table 58).

Table 58. Types of Roads Travelled by Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Roads Travelled, %							
				Interstate		Local		Highway		Rural	
				N	%	N	%	N	%	N	%
Fine et al.[122]	2012	50	Long distance	49	98	0	0	1	2	0	0
Total (Mean)			**--**	**49**	**(98)**	**0**	**0**	**1**	**(2)**	**0**	**0**

Motorcoach/bus Drivers

The Howarth study aimed to investigate the relationship between work shift schedules, sleep length, and various measures of fatigue in transit bus operators. Participants of this study were classified as either straight shift-drivers or split shift-drivers. As part of the study protocol, participants completed the *Transit Bus Operator Survey* designed for this study, which included a question that asked participants where most of their driving time occurs. Possible options included:

- City
- Suburbs
- Equally in the city and suburbs

Data were presented as a function of two transit bus driver work schedules: split-shift and straight-shift drivers. For both groups, the largest percentage of time driving was in the city (56.3 and 69 percent for split-and straight-shifts, respectively). Much less time was reported for driving time in the suburbs (11.3 and 6.9 percent for split and straight shifts, respectively). Summary data is shown in Table 59.

Table 59. Prevalence of Types of Roads Travelled by Motorcoach/bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Roads Travelled, %					
				City		Suburbs		Equally in City/Suburbs	
				N	%	N	%	N	%
Howarth[126]	2002	72	Local	NR	56.3	NR	11.3	NR	32.4
		30	Local	NR	69	NR	6.9	NR	24.1
Total (Mean)		**102**	**--**	**NR**	**(56.3)**	**NR**	**(11.3)**	**NR**	**(32.4)**

NR – Not Reported

Truck and Motorcoach/bus Driver Comparison on Roads Travelled

Data from one included study (Fine et al., 2012) of long-haul truck drivers found that 98 percent of drivers spent most of their driving time on the interstate. While not surprising for this sample of drivers, this study included only 50 participants and thus likely does not represent an accurate distribution of time spent on interstate roads for the larger population of commercial truck drivers. Similarly, data from only one study (Howarth, 2002) of transit bus operators in a Northeast city of the United States found that both split-shift and straight-shift drivers spend a large part of their driving time on city roads, and to a lesser degree both city and suburban roads, but does not provide sufficient data for generalizing motorcoach/bus drivers. As such, we are unable to draw definitive conclusions about potential differences between coach and truck drivers for the types of roads typically travelled.

Distance Travelled

Six truck driver studies and one coach driver study met the inclusion criteria for distance driven.

Truck Drivers

Distance travelled was captured in two different ways in included studies: 1) the average number of miles per trip, and 2) average number of miles driven per week.

Miles per Trip

Four included truck driver studies (Beilock et al., 2003[113]; Fine et al., 2012[122]; Rodriguez et al., 2006[136]; and Rodriguez et al., 2003[137]) reported data on miles driven per trip. Summary data from these studies is shown in Table 60. Beilock did not report the average number of miles driven. Rather, this study categorized drivers into three mileage categories (ie, ≤500, 501-1,000, and >1,000 miles). Among the three studies reporting average miles driven per trip, the weighted average for close to 14,000 drivers was 557.80 miles per trip. Although not directly comparable, the Beilock study found that 25 percent and 66 percent of drivers travelled 501 to 1,000 miles and over 1,000 miles per trip, respectively.

Table 60. Truck Drivers' Average Miles Driven Per Trip

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Miles Driven Per Trip	
				Average	Other
Beilock[1][113]	2003	1,624	Long distance	NR	≤ 500 miles: 9% 501 to 1,000 miles: 25% > 1,000 miles: 66%
Fine et al.[122]	2012	50	Long distance	875	NR
Rodriguez et al.[136]	2006	2,368	Long distance	571	NR
Rodriguez et al.[137]	2003	11,540	Long distance	575.8	NR
Total (Mean)		13,958[1]	--	(557.80*β)	--

NR – Not reported
1 Beilock was not included in overall total of drivers because it did not provide comparable data
β – Adjusted for missing data; * Weighted mean

Average Miles Driven per Week

Two included truck driver studies (Crum et al., 2002[119]; and Morrow and Crum, 2004[45]) evaluated the mean number of miles driven by truck drivers per week. Between the two studies, drivers drove, on average, 2,449 miles per week, as shown in Table 61.

Table 61. Average Miles Driven Per Week by Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Miles Driven Per Week
				Average
Crum et al.[119]	2002	502	Long distance	2,848
		279	Long distance	1,966
Morrow & Crum[45]	2004	116	All types	1,890
Total (Mean)		897	--	(2,449)

Motorcoach/bus Drivers

Only one study (Crum et al., 2002[119]) of motorcoach drivers provided relevant data. In this study, both the range and mean number of miles driven on each trip, and per week were reported. Additionally, data were reported from a survey of 122 individual drivers, as well as a sample of individuals representing 66 different motormotorcoach/bus companies.

For the data from the 122 individual coach drivers (1 to 2 from each of the 66 represented companies), Crum et al. found that drivers reported travelling:

- An average of 300 miles per trip; range between 100 and 3,500 miles per trip.
- An average of 1,200 miles a week; range between 200 and 2,500 miles per week.

Based on data from representatives of the 66 coach agencies, Crum et al. found:

- An average of 250 miles per trip; range between 50 and 1,200 miles per trip.
- An average of 1,200 miles a week; range between 375 and 2,700 miles per week.

Truck and Motorcoach/bus Driver Comparison on Distance Travelled

Data retrieved from the eight included studies revealed (see Table 62):

- Truck drivers' average length per trip (557.8 miles) is longer than the average travelled by coach drivers (250 to 300 miles), with a mean difference of at least 257.8 miles.
- On average, coach drivers drive nearly half as many miles per week than truck drivers: 1,200 miles vs. 2,449 miles.

These findings are derived from limited data and a small sample size of motorcoach/bus drivers.

Table 62. Mean Miles Travelled by Truck and Coach Drivers

Population	No. of Studies	Total No. of participants	Findings on Distance Travelled			
			Miles Per Trip		Miles Per Week	
			Average	Range	Average	Range
Truck drivers	4	13,958	557.80	571 to 875*	2,449	1,890 to 2,848*
Coach drivers	1	122	250 to 300	100 to 3,500**	1,200	200 to 2,700**

* Range is represented by the mean of multiple studies.
** Range is represented by a single study.

Driving Time

Five truck driver studies and one bus driver study met the inclusion criteria for assessing driving time in a day.

Truck Drivers

Five truck driver studies (Blanco et al., 2011[114]; Layne et al., 2009; McCartt et al., 2008[130]; Reed and Cronin, 2003[134]; and Stasko and Neale, 2007[142]) assessed driving time in three ways.

- Percent of shift spent driving
- Hours and minutes spent driving per day
- Time spent driving before stop

Percent of shifts spent driving

Blanco et al., which addressed 75 long-haul and 21 line-haul drivers' overall time driving during a shift, found that both groups of drivers spent, on average, 65.9 percent of their shifts driving. Separately, long-haul drivers spend 67.7 percent of their shift driving, and line-haul drivers spend 59.9 percent of their shift driving (see Table 63).

Table 63. Percent of Truck Drivers' Shift Spent Driving

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Driving Time Per Shift %
Blanco et al.[114]	2011	75 (Long-haul)	Long distance	67.7
		21 (Line-haul)	Long distance	59.9
Total (Weighted mean)		**96**	**--**	**(65.9)**

Hours spent driving

Three truck driver studies – Layne et al., McCartt et al., and Reed and Cronin – assessed the average number of hours spent driving. The findings show (see Table 64 and Table 65):

- Approximately 39 percent of truck drivers drive more than 10 hours a day.
- More than 60 percent drive 10 hours or less a day.
- About 30 percent of drivers drive between 10.1 and 11 hours per day.
- About 9 percent of drivers drive more than 11 hours per day.
- More drivers (73 percent) drove fewer than 10 hours a day before the Jan. 4, 2004, rule change than after the rule change (61 percent).
- As a result of the rule change, more drivers (39 percent) drove 10.1 hours or more a day compared to before the rule change (27 percent).

Table 64. Truck Drivers' Daily Hours of Driving

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Driving Time Per Shift %
Layne et al.[130]	2009	50	Long distance	Drive 10 hours or less per day: • Men: 63% • Women: 55%
Reed & Cronin[134]	2003	284	Long distance	Average driving hours per day: 9.4

Table 65. Truck Drivers' Daily Hours of Driving (Before/After 2004 Rule Change)

Study	Year	Number of Drivers		Types of Driving (Long distance, Local or Regional)	Hours Per Day of Driving N (%)		
					≤ 10	10.1 to 11	> 11
McCartt et al.[132]*	2008	323 (PA: 2004)	Before 2004 rule	Long distance	249 (77)	36 (11)	36 (11)
			After rule		200 (62)	97 (30)	26 (8)
		319 (OR: 2004)	Before 2004 rule		217 (68)	57 (18)	45 (14)
			After rule		185 (58)	93 (29)	41 (13)

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Hours Per Day of Driving N (%) ≤ 10	10.1 to 11	> 11
		216 (PA: 2005)		138 (64)	65 (30)	13 (6)
		239 (OR: 2005)		148 (62)	74 (31)	17 (7)
Total (Mean) [Before rule]**		**642**	**--**	**466 (73)**	**93 (14)**	**81 (13)**
Total (Mean)* [2004-2005]**		**1,097**	**--**	**671 (61)**	**329 (30)**	**97 (9)**

PA – Pennsylvania; OR - Oregon
**Mean findings for driving time before the Jan. 4,2004, hour-of-service rule change.
***Excludes findings of "Before rule" changed Jan. 4,2004.

Time Spent Driving Before Stop

Stasko and Neale addressed drivers' time spent driving before a stop, finding on average that (see Table 66):

- Nearly 11 percent drive 5 to 7.5 hours before making a stop;
- 50 percent drive 7.5 to 10 hours before stopping; and
- 39 percent drive more than 10 hours before stopping.

Table 66. Truck Drivers' Time Spent Driving Before Stop

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Time Spent Driving Before Stop N (%) 5 to 7.5 hours	7.6 to 10 hours	> 10 hours
Stasko & Neale[142]	2007	28	Long distance	3 (10.7)	14 (50)	11 (39.3)

Motorcoach/bus Drivers

One bus driver study (Sando et al., [138]) assessed mean driving time for all drivers and straight-shift and split-shift drivers in two ways: (1) hours per day and (2) hours per week (see Table 67). The data come from two datasets: 1) surveys from 266 transit drivers from six Florida agencies; and 2) records for 972 transit drivers from four Florida agencies.

Driving time per day

According to records data, Sando et al. found the mean driving time for straight-shift drivers to be 8 hours and 35 minutes. More driving time hours were reported for split-shift drivers: 9 hours and 46 minutes. Among its surveyed drivers, Sando et al. found the mean driving time for all drivers to be 8.69 hours.

Driving time per week

On average, Sando et al. found that its surveyed bus drivers drive 42.64 hours a week on average. From record data, Sando et al. found the split-shift workers drive 4.13 more hours a week than straight-shift workers. Straight-shift drive 43.52 hours a week on average, and split-shift workers drive 47.65 hours a week.

Table 67. Motorcoach/bus Drivers' Driving Time Per Day and Week

Study	Year	Number of Drivers	Types of Driving (Long distance, Local, Regional)	Driving Time Findings	
				Straight Shift	Split Shift
Driving Time Per Day					
Sando et al.[138]	2010	148	Local	• Mean: 8.34 • SD: 0.82 • Range: 6.67 to 10.21	• Mean: 9.37 • SD: 1.69 • Range: 7.84 to 14.91
		268		• Mean: 8.70 • SD: 0.96 • Range: 7.50 to 12.84	• Mean: 9.73 • SD: 1.87 • Range: 7.70 to 14.55
		396		• Mean: 8.70 • SD: 1.54 • Range: 2.87 to 11.75	• Mean: 10.09 • SD: 3.12 • Range: 2.87 to 22.90
		160		• Mean: 8.26 • SD: 0.88 • Range: 6.40 to 10.0	• Mean: 9.36 • SD: 1.95 • Range: 6.40 to 15.30
		Combined		• Mean: 8.58 • SD: 1.23 • Range: 2.87 to 12.84	• Mean: 9.77 • SD: 2.49 • Range: 2.87 to 22.90
		266		• Driving hours per day: 8.69 hours	
Driving Time Per Week					
Sando et al.[138]	2010	148	Local	• Mean: 40.24 • SD: 2.70 • Range: 32.10 to 60.50	• Mean: 42.26 • SD: 3.71 • Range: 32.10 to 60.50
		268		• Mean: 46.39 • SD: 6.99 • Range: 32.60 to 64.22	• Mean: 51.79 • SD: 10.99 • Range: 32.60 to 85.67
		396		• Mean: 43.90 • SD: 9.09 • Range: 6.25 to 65.02	• Mean: 47.89 • SD: 12.62 • Range: 6.25 to 80.22
		160		• Mean: 41.26 • SD: 3.71 • Range: 27.0 to 56.0	• Mean: 46.73 • SD: 9.41 • Range: 27.0 to 70.50
		Combined		• Mean: 43.52 • SD: 7.50 • Range: 6.25 to 65.02	• Mean: 47.65 • SD: 11.06 • Range: 6.26 to 85.67
		266		• Mean: 42.64	

NR – Not reported; SD – Standard deviation

Truck and Motorcoach/bus Driver Comparison on Time Driving and Stops

Data from the six included studies revealed:

- Truck drivers (long-haul and line-haul) spend nearly 66 percent of their shift driving.
- About 60 percent drive 10 hours or less per day, and 9 percent drive more than 11 hours. Approximately 39 percent drive 10.1 hours or more a day, on average.
- The majority of bus drivers drive approximately 8 and 9 hours a day to 42 and 44 hours a week.
- Split-shift bus drivers drive about four more hours a week than straight-shift local bus drivers: 47.65 hours vs. 43.52 hours, respectively.

The results of these studies could be misleading as there is a paucity of data and the sample sizes are small.

Total Time Worked

Three truck driver studies, three bus driver studies, and one coach driver study met the inclusion criteria for assessing total time worked (see Table 57).

Truck Drivers

Days per Trip/Month on the Road

Three included truck driver studies (Solomon et al., 2004[141]; McCartt et al.[132]; and Stasko and Neale, 2007[142]) evaluated the number of days that truck drivers are on the road. More specifically, Solomon assessed the number of days drivers were away per trip and per month; McCartt et al. assessed the number of days truck drivers were on the road during one stretch; and Stasko and Neale assessed how long typical trips take and the longest trip in the last year.

The findings of Solomon et al., which assess long-haul drivers, showed (see Table 68):

- Few drivers are on the road less than 5 days a week.
- 93 percent of drivers are on the road 5 or more days per trip, with:
  - 29 percent on the road for 5 to 10 days
  - 16 percent on the road for 11 to16 days
  - 13 percent on the road for 17 to 22
- 58 percent of drivers are on the road 23 or more days of the month.

Table 68. Days Per Trip and Days Per Month for Long-Haul Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Days Per Trip and Days Per Month N (%)				
				<5 days	5-10 days	11-16 days	17-22 days	>22 days
Days Per Trip								
Solomon et al.[141]	2004	512	Long distance	38 (7)	146 (29)	82 (16)	66 (13)	180 (35)
Days Per Month								
Solomon et al.[141]	2004	519	Long distance	7 (1)	18 (4)	28 (5)	165 (32)	301 (58)

The findings of McCartt et al., which assessed long-haul drivers before and after the HOS rule change on Jan. 4, 2004, revealed that between 2003 and 2005 (see Table 69):

- 33 percent of truck drivers, on average, spent five days or less on the road during a stretch; however, the study also found that:
  - Before the rule change, 35 percent spent less five days or less
  - After the rule change, 32 percent spent five days or less
- 17 percent spent 6 to 7 days on the road at a time; however, the study also found that:
  - Before the rule change, 18 percent spent 6 to 7 days on the road
  - After the rule change, 17 percent spent 6 to 7 days on the road
- 18 percent spent 8 to 14 consecutive days on the road; however, the study also found:
  - Before the rule change, 16 percent spent 8 to 14 days on the road
  - After the rule change, 18 percent spent 8 to 14 days on the road
- 32 percent of truck drivers spent more than 15 days on the road during a stretch; however, the study also found that:
  - Before the rule change, 31 percent spent more than 15 days on the road
  - After the rule change, 33 percent spent 8 to 14 days on the road

Table 69. Days Per Stretch for Long-Haul Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Days on Road during a Stretch N (%)			
				≤ 5 Days	6-7 Days	8-14 Days	≥ 15 Days
McCartt et al.[132]*	2008	354 (PA: 2003)	Long distance	156 (44)	64 (18)	49 (14)	85 (24)
		338 (OR: 2003)		88 (26)	58 (17)	64 (19)	128 (38)
		356		142 (40)	57 (16)	57 (16)	100 (28)

		(PA: 2004)					
		350 (OR: 2004)		77 (22)	63 (18)	67 (19)	143 (41)
		236 (PA: 2005)		89 (38)	45 (19)	38 (16)	64 (27)
		287 (OR: 2005)		78 (27)	43 (15)	63 (22)	103 (36)
Total (Mean) [All Years]		**1,921**	**--**	**630 (33)**	**330 (17)**	**338 (18)**	**623 (32)**
Total (Mean) [2003]**		**692**	**--**	**244 (35)**	**122 (18)**	**113 (16)**	**213 (31)**
Total (Mean)* [2004-2005]**		**1,229**	**--**	**386 (32)**	**208 (17)**	**225 (18)**	**410 (33)**

PA – Pennsylvania; OR - Oregon
* Denotes that Cochran-Mantel-Haenszel chi-square test indicates 2003 vs. 2004 and 2004 vs. 2005 differences are significant in at least one state ($p<0.05$).
**Includes on 2003 data, before the Jan. 4,2004, hour-of-service rule change.
***Excludes 2003 data that was retrieved before the Jan. 4,2004, hour-of-service rule change.

The findings of Stasko and Neale, which assessed long-haul drivers, show (see Table 70):

- 63 percent of drivers are typically on the road less than seven days per trip.
- 37 percent of drivers are typically on the road for a week or longer per trip.
- 35 percent of drivers' longest trip within the last year took a month or more.

Table 70. Typical Number of Days on Road and Longest Trips for Long-Haul Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Days on Road N (%)
Typical Number of Days on Road				
Stasko and Neale[142]	2007	30	Long distance	**< 7 days:** 19 (63) **7-13 days:** 4 (13) **14-20 days:** 2 (7) **21-27 days:** 2 (7) **28-119 days:** 2 (7) **Year-round:** 1 (3)
Longest Trip in Last Year				
Stasko and Neale[142]	2007	20	Long distance	**2 weeks:** 6 (30) **3 weeks:** 7 (35) **A month or more:** 7 (35)

Motorcoach/bus Drivers

One coach driver study (Crum et al., 2002[119]) and three bus driver studies (Escoto and French, 2012[121]; Howarth, 2002[126], and Sando et al., 2010[138]) assessed total time worked for one or more of the following categories:

- Hours in a day
- Non-driving hours per day
- Days per week

Crum et al. provided data from 122 coach drivers and 66 motorcoach companies. Escoto and French evaluated 773 urban bus drivers in four transit garages in a Midwestern city. Howarth provided data on 30 straight-shift workers and 72 split-shift workers from a state-funded agency in the Northeast. Sando et al. provided information from its survey of 266 drivers from six transit agencies in Florida; no data were available from its records collection of 972 drivers from four Florida agencies.

Hours a day

Sando et al. reported the mean time of total hours worked 10 hours and 36 minutes, ranging from a minimum of 9 hours and a maximum of 11 hours and 8 minutes. Howarth reported a mean time of 8 hours and five minutes for its 30 straight-shift drivers, with a minimum of 7 and half hours and a maximum of 9 and half hours. Howarth's split-shift drivers worked a mean of 7 hours and 49 minutes, with a minimum of 6 hours and 48 minutes and a maximum of 8 hours and 55 minutes. Table 71 shows the results of the two studies.

Table 71. Bus Drivers' Total Hours Worked Per Day

<table>
<tr><th rowspan="2">Study</th><th rowspan="2">Year</th><th rowspan="2">Number of Drivers</th><th rowspan="2">Types of Driving (Long distance, Local, Regional)</th><th colspan="2">Driving Time Findings</th></tr>
<tr><th>Straight Shift</th><th>Split Shift</th></tr>
<tr><td>Howarth[126]</td><td>2002</td><td>102
(30 straight-shift and 72 split-shift drivers)</td><td>Local</td><td>• Mean time on duty: 8 hours, 5 minutes
• Range of 7.5 hours to 9.5 hours</td><td>• Mean time on duty: 7 hours, 48 minutes
<u>1st block</u>: 3 hours, 42 minutes (SD=74.2, range 90 minutes to 6 hours, 20 minutes)
<u>2nd block</u>: 4 hours, 6 minutes (SD=75.1, range 1 hour, 15 minutes to 6 hours, 20 minutes)</td></tr>
<tr><td>Sando et al.[138]</td><td>2010</td><td>266</td><td>Local</td><td colspan="2">• 10 hours and 36 minutes
• Range of 9 to 11 hours and 8 minutes</td></tr>
</table>

SD – Standard deviation

Non-driving hours per day

Sando et al. reported the mean number of hours on duty per day with no driving to be 1.01 hours, ranging from a minimum 12 minutes to a maximum of 2 hours.

Hours per week

Crum et al. reported that coach drivers worked between 40 and 48 hours a week. Based on survey data from 122 coach drivers, participants reported working 40 hours a week, with a range between 6 and 75 hours a week. Representatives from the 66 coach companies reported coach drivers worked an average of 48 hours a week, with a range of 5 to 75 hours.

Escoto and French reported similar findings among its 773 urban bus drivers, 65 percent of whom worked between 40 and 49 hours a week. A small number (9 percent) worked 50 or more hours. Approximately 27 percent worked less than 40 hours a week. Table 72 shows the results of the two studies.

Table 72. Motorcoach/bus Drivers' Total Hours Worked Per Week

Study	Year	Number of Drivers	Types of Driving (Long distance, Local, Regional)	Driving Time Findings Per Week
Crum et al.[119]	2002	122 coach drivers	Long distance	• Mean: 40 hours • Range: 6 hours to 75 hours
		Reps from 66 coach companies	Long distance	• Mean: 48 hours • Range: 5 hours to 75 hours
Escoto and French[121]	2012	773 urban drivers	Local	• 206 (27 percent) work < 40 hours • 499 (65 percent) work between 40 and 49 hours • 68 (9 percent) work ≥ 50 hours

Days per week

Sando et al. reported the mean number of days worked among 266 drivers to be 5.22 days, ranging from a minimum of 5.09 days and a maximum of 5.46 days.

Truck and Motorcoach/bus Driver Comparison on Total Time Worked

Data retrieved from seven included studies revealed differing attributes concerning truck and motorcoach/bus drivers. For truck drivers, the number of days on the road is assessed. For motorcoach/bus drivers, the number of hours per day and week are primarily assessed. Due to the type of data presented, a comparison between the two driver groups is not possible. The following provides a summary of the data:

- Long-haul truck drivers' days on the road varies, depending on the job. The findings of the three included studies are:
  - **Solomon et al., 2004:** 93 percent of drivers are on the road 5 or more days per trip; and 58 percent of drivers are on the road 23 or more days of the month.
  - **McCartt et al., 2008:** Between 2003 and 2005, 33 percent spent 5 days or less on the road during a stretch; 17 percent spent between 6 and 7 days; 18 percent spent between 8 and 14 days; and 32 percent spent more than 15 days.
    - Before the rule change, in 2003, however, 35 percent spent 5 days or less on the road during a stretch; 18 percent spent between 6 and 7 days; 16 percent spent between 8 and 14 days; and 31 percent spent more than 15 days.
    - After the rule change, in 2004 and 2005, however, 32 percent spent 5 days or less on the road during a stretch; 17 percent spent between 6 and 7 days; 18 percent spent between 8 and 14 days; and 33 percent spent more than 15 days.

- **Stasko and Neale, 2007:** 63 percent of drivers are typically on the road less than 7 days per trip; 37 percent of drivers are typically on the road for a week or longer per trip; and 35 percent of drivers' longest trip within the last year took a month or more.

- For coach drivers, the mean total hours worked each week was between 40 and 48 hours.
- For bus drivers, a mean of 40 to 49 hours was reported. The mean time per day varied between 8 and 10.5 hours. A small sample study of 102 drivers reported that split-shift drivers worked slightly less than straight-shift drivers, which conflicts with data reported in *Driving Time* (see above). The mean number of days reported was 5.22 days, and the mean number of hours on-duty, no driving, was 1.01 hours.

Loading Requirements

Two included studies (Blanco et al., 2011[114]; and Dinges and Maislin, 2006[80]) assessed loading requirements for truck drivers (see Table 57). No studies were found that evaluated loading requirements for motorcoach/bus drivers.

Truck Drivers

The two included studies reported load requirements differently from one another. Blanco et al. reported the percent of a shift spent doing heavy work, and Dinges and Maislin tabulated the time spent loading and unloading before a run. Their results revealed (see Table 73):

- 4.2 percent of long-haul and line-haul drivers' shifts are spent doing heavy work, such as loading and unloading. Separately, line-haul drivers spent 12 percent of their shift doing heavy work, and long-haul spent 2 percent.
- 95.5 percent of truck drivers said they spent less than 1 hour of their shift loading and unloading.

Table 73. Loading Requirements for Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Loading Requirements N (%)	
Blanco et al.[114]	2011	75 (Long-haul)	Long distance	2	Weighted mean: 4.2
		21 (Line-haul)	Long distance	12	
Dinges & Maislin[80]	2006	2,280	All types	Time spent loading/unloading before run: <1 hour: 1,675 (96.5), SE=0.4 1-2 hours: 18 (0.8), SE=0.2 3-4 hours: 26 (1.6), SE=0.3 5-6 hours: 2 (0.1), SE=0.1	

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Loading Requirements N (%)
				7-8 hours: 1 (0.1), SE=0.1 9-10 hours: 6 (0.3), SE=0.1 >10 hours: 8 (0.5), SE=0.2

Motorcoach/bus Drivers

No studies met the inclusion criteria on motorcoach/bus drivers' loading requirements.

Truck and Motorcoach/bus Driver Comparison on Loading Requirements

Data retrieved from two included studies revealed (see Table 73):

- Long-haul truck drivers spend a small amount of time loading and unloading each shift.
  - On average, 4.2 percent of truck drivers' shift is spent loading and unloading.
  - 95.5 percent of truck drivers said they spent less than 1 hour of their shift loading and unloading.

The results of these studies could be misleading as there is a paucity of data. No studies met the inclusion criteria for motorcoach/bus drivers' loading requirements.

Light Work Duties (Including Paperwork)

Only one included study (Blanco et al., 2011[114]) evaluated the time truck drivers spend performing light duties, including paperwork (see Table 57). No motorcoach/bus driver studies met the inclusion criteria for this subject.

Truck Drivers

Blanco et al., the only study to evaluate light duty work, found that long-haul truck drivers spend 17.4 percent of their shifts performing light duties, and line-haul workers spend 25.4 percent, as shown in Table 74.

Table 74. Percent of Shift Spent Doing Light Work by Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long-haul, Local or Regional)	Findings on Light Work Duty Average % of shift
Blanco et al.[114]	2011	75	Long distance (Long-haul)	17.4
		21	Long distance (Line-haul)	25.4
Total (Weighted mean)		**96**	**--**	**19.15**

Motorcoach/bus Drivers

No studies met the inclusion criteria on motorcoach/bus drivers' time spent on light work duties.

Truck and Motorcoach/bus Driver Comparison on Light Work Duties

Data retrieved from one included study reveals (see Table 74):

- Long-haul drivers spend 17.4 percent of their time shift doing light work, and line-haul drivers spend 25.4 percent doing the same.

The results of this section could be misleading as there is a paucity of data and the sample sizes are small. No motorcoach/bus driver studies met the inclusion criteria for this category.

Pre-Trip Operations

One included study (Dinges and Maislin, 2006[80]) met the inclusion criteria for evaluating the amount of time spent performing pre-trip operations (see Table 75).

Truck Drivers

Dinges and Maislin, the only study to evaluate pre-trip operations, found (see below):

- Approximately 95 percent of drivers spend less than one hour checking or repairing their heavy vehicles before a run.
- Approximately 74 percent of drivers spend less than one hour working in the yard before a run.

Table 75. Time Spent Performing Pre-Trip Operations

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Pre-Trip Operations: Time Spent Checking/Repairing Heavy Vehicles Before a Run	Findings on Pre-Trip Operations: Time Spent in Yard Before a Run[1]
				N (%)	N (%)
Dinges & Maislin[80]	2006	1,911	All types	**<1 hour:** 1,814 (94.8), SE=0.5 **1-2 hours:** 69 (3.6), SE=0.4 **3-4 hours:** 17 (0.9), SE=0.2 **5-6 hours:** 3 (0.2), SE=0.1 **7-8 hours:** 2 (0.2), SE=0.1 **9-10 hours:** 2 (0.2), SE=0.1 **>10 hours:** 4 (0.2), SE=0.1	**<1 hour:** 1,376 (73.9), SE=1.0 **1-2 hours:** 384 (20.5), SE=0.9 **3-4 hours:** 87 (4.4), SE=0.5 **5-6 hours:** 16 (0.9), SE=0.2 **7-8 hours:** 4 (0.3), SE=0.1 **9-10 hours: 1** (0), SE=0 **>10 hours:** 0 (0), SE=NA

SE – Standard error

1 The total number of driver participants who responded to question of "time spent in yard" was 1,868.

Motorcoach/bus Drivers

No studies met the inclusion criteria on motorcoach/bus drivers' time spent performing pre-trip operations. No studies motorcoach/bus studies met the inclusion criteria.

Truck and Motorcoach/bus Driver Comparison on Pre-Trip Operations

Data retrieved from one included study revealed (see Table 75):

- Approximately 95 percent of drivers spend less than one hour checking or repairing their heavy vehicles before a run.

- Approximately 74 percent of drivers spend less than one hour working in the yard before a run.

The results of Dinges and Maislin could be misleading as there is a paucity of data to reproduce its findings. No studies met the inclusion criteria for motorcoach/bus drivers' pre-trip operations.

Opportunities for Rest

Four truck driver studies and two bus driver studies met the inclusion criteria for evaluating opportunities for rest (see Table 76).

Truck Drivers

This section comprises five parts, evaluating: 1) difficulty finding a place to rest, 2) number of hours off duty in a daily shift, 3) average hours off before beginning new weekly shift, 4) average driving time before taking a break, and 5) average break length.

Difficulty Finding a Place to Rest

Two included truck driver studies (Crum et al., 2002[119]; and Morrow and Crum, 2004[45]) found that 46 percent of drivers said they have a difficult time finding a place to rest.

Table 76. Prevalence of Truck Drivers' Difficulty Finding a Place to Rest

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Difficulty Finding a Place to Rest			
				Frequently a Problem		Rarely a Problem	
				N	%	N	%
Crum et al.[119]*	2002	502	Long distance	NR	48.7	NR	51.3
Morrow & Crum[45]	2004	116	All types	41	35.7	75	63.7
Total (Mean)		**618**	**--**	**286**	**(46.28)**	**332**	**(53.72)**

NR – Not reported
* Study did not provide number of participants who responded to the attribute, only the percentage of participants. For the purpose of calculating an overall mean of the studies' data, a number was configured based off the percentage and total number of participants.

Number of Hours Off in a Daily Shift

One included study focused on the time drivers have off before returning to the next day's shift. McCartt et al. (2008)[132] assessed four groups of drivers, finding that before the hours-of-service rule change of 2004 (see Table 77):

- 20 percent had less than 8 hours off until their next shift
- About 20 percent had 8 to 9.9 hours of rest until the next shift
- Approximately 60 percent had 10 hours or more

After the rule change, 10 percent more drivers had 10 or more hours off until the next shift. The findings showed:

- 25 percent have less than 8 hours off until their next shift
- About 5 percent have 8 to 9.9 hours of rest until the next shift

- Approximately 70 percent have 10 hours or more

Table 77. Truck Drivers' Hours Off in a Daily Shift

Study	Year	Number of Drivers		Types of Driving (Long distance, Local or Regional)	Findings on Hours Off Until Next Day's Shift N (%)		
					< 8 Hours	8-9.9 Hours	≥ 10 Hours
McCartt et al.[132]	2008	323 (PA: 2004)	Before 2004 rule	Long distance	77 (24)	68 (21)	178 (55)
			After rule		68 (21)	16 (5)	239 (74)
		319 (OR: 2004)	Before 2004 rule		54 (17)	61 (19)	204 (64)
			After rule		51 (16)	19 (6)	249 (78)
		216 (PA: 2005)			78 (36)	4 (2)	134 (62)
		239 (OR: 2005)			78 (33)	12 (5)	148 (62)
Total (Mean)* [Before rule]		**642**		**--**	**131 (20)**	**129 (20)**	**382 (60)**
Total (Mean) [2004-2005]**		**1,097**		**--**	**275 (25)**	**51 (5)**	**770 (70)**

PA – Pennsylvania; OR – Oregon
*Mean findings for driving time before the Jan. 4,2004, hour-of-service rule change.
**Excludes findings of "Before rule" change in January 2004.

Average Hours Off Before Beginning New Weekly Shift

McCartt et al. also evaluated the mean number of hours drivers have off before beginning a new weekly shift. It assessed two groups of drivers, collectively finding (see Table 78):

- 12 percent have less than 34 hours off until the new weekly shift begin.
- 45 percent have 34 to 47.9 hours off until they begin their new weekly shift.
- 43 percent have more than 48 hours off until the next week.

Table 78. Prevalence of Truck Drivers' Hours Off Before Beginning New Weekly Shift

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Hours Off Before Beginning New Weekly Shift					
				< 34 Hours		34 to 47.9 Hours		> 48 Hours	
				N	%	N	%	N	%
McCartt et al.[132]*	2008	356	Long distance	32	9	182	51	142	40
		350		56	16	151	43	143	41
		236		31	13	99	42	106	45
		287		26	9	123	43	138	48
Total (Mean)		**1,229**	**--**	**145**	**(12)**	**555**	**(45)**	**529**	**(43)**

*The 2003 data, before the hours of service rule change on Jan. 4, 2004,were not provided in McCartt et al.[132]

Average Driving Time Before Taking a Break

Dinges and Maislin (2006)[80] evaluated the average driving time before taking a break among 2,252 drivers, finding a mean of 3.7 hours.

Average Break Length

Dinges and Maislin evaluated the average break length among 2,252 drivers, finding (see

Table 79):

- The mean break length is 45 minutes.
- 50 percent of drivers break for 30 minutes to 1 hour.
- Nearly 1 in 3 drivers takes less than 30 minutes for a break.

Table 79. Average Break Length for Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Average Break Length Length of Workday Break N (%)
Dinges & Maislin[80]	2006	2,252	All types	**< 30 minutes:** 741 (31.7), SE=1.0 **30 minutes to 1 hour:** 1,113 (49.7), SE=1.1 **1 hour to 90 minutes:** 247 (11.5), SE=0.7 **90 minutes to 2 hours:** 74 (3.4), SE=0.4 **2 or more hours:** 77 (3.6), SE=0.4

Motorcoach/bus Drivers

Two motorcoach/bus studies (Howarth, 2002[126]; and Sando et al, 2010[138]) met the inclusion criteria for this section, assessing the mean duration of breaks for split-shift drivers. Howard found the mean break time to be 4 hours and 25 minutes, and Sando et al. found it to be 3 hours and 3 minutes. Between the two studies, the mean break time is 3 hours and 26 minutes.

Table 80. Average Break Length for Split-Shift Bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long-haul, Local or Regional)	Findings on Average Break Length for Split-Shift Drivers	
				Mean Hours	Range
Howarth[126]	2002	102	Local	4 hours and 25 minutes	1 hour and 15 minutes to 6 hours and 10 minutes.
Sando et al.	2010	266	Local	3 hours and 3 minutes	30 minutes to 8 hours
Total (Mean)		**368**	**Local**	**(3 hours and 26 minutes)**	**30 minutes to 8 hours**

Truck and Motorcoach/bus Driver Comparison on Opportunities for Rest

Data retrieved from the six included studies revealed:

- Nearly half of truck drivers have a difficult time finding a place to rest.
- Approximately 70 percent of truck drivers have 10 hours or more off per shift day.

- 43 percent of truck drivers have more than 48 hours off until their new weekly shift begins.
- Truck drivers, on average, drive 3.7 hours before taking a 45-minute break.
- Split-shift motorcoach/bus drivers have a mean break of nearly 3 hours and 26 minutes.

The data for these findings are limited due to a paucity of data and small sample sizes.

Section Summary for Key Question 3B

Roads Travelled

Data from one included study (Fine et al., 2012) of long-haul truck drivers found that 98 percent of drivers spent most of their driving time on the interstate. While not surprising for this sample of drivers, this study included only 50 participants and thus likely does not represent an accurate distribution of time spent on interstate roads for the larger population of commercial truck drivers. Similarly, data from only one study (Howarth, 2002) of transit bus operators in a Northeast city of the United States found that both split-shift and straight-shift drivers spend a large part of their driving time on city roads, and to a lesser degree both city and suburban roads, but does not provide sufficient data for generalizing motorcoach/bus drivers. As such, we are unable to draw definitive conclusions about potential differences between coach and truck drivers for the types of roads typically travelled.

Distance Travelled

Data retrieved from seven included studies revealed:

- Truck drivers' average length per trip (557.8 miles) is longer than the average travelled by coach drivers (250 to 300 miles), with a mean difference of at least 257.8 miles.
- On average, coach drivers drive nearly half as many miles than truck drivers per week: 1,200 miles vs. 2,449 miles.

A paucity of data makes it difficult to ascertain the accuracy of these findings.

Driving Time

Data from six included studies revealed:

- Truck drivers (long-haul and line-haul) spend nearly 66 percent of their shift driving.
- About 60 percent drive 10 hours or less per day, and 9 percent drive more than 11 hours. Approximately 39 percent drive 10.1 hours or more a day, on average.
- The majority of bus drivers drive approximately 8 to 9 hours a day and 42 to 44 hours a week.
- Split-shift bus drivers drive about four more hours a week than straight-shift local bus drivers: 47.65 hours vs. 43.52 hours, respectively.

The results of these studies could be misleading as there is a paucity of data and the sample sizes are relatively small.

Total Time Worked

Data from seven included studies revealed:

- The number of long-haul truck drivers' days on the road varies, depending on the job. The findings of the three included studies are:
    - **Solomon et al., 2004:** 93 percent of drivers are on the road 5 or more days per trip; and 58 percent of drivers are on the road 23 or more days of the month.
    - **McCartt et al., 2008:** 33 percent spent less than 5 days on the road during a stretch; 35 percent spent between 6 and 14 days; and 32 percent spent more than 15 days on the road during a stretch.
    - **Stasko and Neale, 2007:** 63 percent of drivers are typically on the road less than 7 days per trip; 37 percent of drivers are typically on the road for a week or longer per trip; and 35 percent of drivers' longest trip within the last year took a month or more.
- For coach drivers, the mean total hours worked each week was between 40 and 48 hours.
- For bus drivers, a mean of 40 to 49 hours was reported. The mean time per day varied between 8 and 10.5 hours. A small sample study of 102 drivers reported that split-shift drivers worked slightly less than straight-shift drivers, which conflicts with data reported in *Driving Time* (see above). The mean number of days reported was 5.22 days, and the mean number of hours on-duty, no driving, was 1.01 hours.

Loading Requirements

Data from two included studies revealed:

- Long-haul truck drivers spend a small amount of time loading and unloading each shift.
    - 2 percent of truck drivers' shift is spent loading and unloading.
    - 95.5 percent of truck drivers said they spent less than one hour of their shift loading and unloading.

The results of these studies could be misleading as there is a paucity of data. No studies met the inclusion criteria for motorcoach/bus drivers' loading requirements.

Light Work Duties

Data from one included study revealed:

- Long-haul drivers spend 17.4 percent of their time shift doing paperwork or other duties considered light work.

A paucity of data makes it difficult to ascertain the accuracy of these findings. No studies met the inclusion criteria for motorcoach/bus drivers' paperwork duties.

Pre-Trip Operations

Data retrieved from one included study revealed:

- Approximately 95 percent of drivers spend less than one hour checking or repairing their heavy vehicles before a run.
- Approximately 74 percent of drivers spend less than one hour working in the yard before a run.

The results of Dinges and Maislin could be misleading as there is a paucity of data to reproduce its findings. No studies met the inclusion criteria for motorcoach/bus drivers' pre-trip operations.

Opportunities for Rest

Data from the six included studies revealed:

- Nearly half of truck drivers have a difficult time finding a place to rest.
- Approximately 70 percent of truck drivers have 10 hours or more off per shift day.
- 43 percent of truck drivers have more than 48 hours off until their new weekly shift begins.
- Truck drivers, on average, drive 3.7 hours before taking a 45-minute break.
- Split-shift motorcoach/bus drivers have a mean break of nearly 3 hours and 26 minutes.

The data for these findings are limited due to a paucity of data and small sample sizes.

Key Question 3C: Work Environment

In this section, we assess the work environment of heavy and tractor-trailer truck drivers and motorcoach/bus drivers, and compare similarities and differences between the two groups.

Heavy and tractor-trailer truck drivers, who held about 1.6 million jobs in 2010, can be away from home for days or weeks at a time[151]. They spend much of this time alone, and it can be a physically demanding job as they drive for long, continuous hours and may be required to load and unload cargo. Due to the risk of traffic crashes, truck driving has a higher risk of injury than most other occupations. Working in this occupation is a major lifestyle choice. Many drivers are employed in general freight trucking. Table 81 lists the industries that employed the most truck drivers in 2010.

Table 81. Industries Employing Heavy and Tractor-Trailer Drivers in 2010

Industry	% of Truck Drivers Employed
General freight trucking	33
Specialized freight trucking	12
Wholesale trade	12
Manufacturing	8

Source: Bureau of Labor Statistics[151]

Transit and intercity bus drivers, who held about 195,000 jobs in 2010, drive through heavy traffic or bad weather, dealing with passengers, who can be unruly[152]. These drivers had a higher rate of work-related injury and illness in 2010 compared to the national average. Most injuries to bus drivers are due to highway crashes. Most drivers work for local governments or urban transit systems, which are private companies that contract with a city or town to provide bus service. Most motorcoach drivers work in the charter bus industry.

Table 82 lists the industries that employed the most transit and intercity motorcoach/bus drivers in 2010.

Table 82. Industries Employing Transit and Intercity Bus Drivers in 2010

Industry	% of Truck Drivers Employed
Local government, excluding education and hospitals	50
Urban transit systems	14
Charter bus industry	9
Other transit and ground passenger transportation	8

Source: Bureau of Labor Statistics[152]

To identify similarities and differences of work environment between truck and motorcoach/bus drivers, we evaluate the following:

- Control over trips (eg, route regularity, flexibility, etc.)
- Interactions with passengers
- Cabin ergonomics
- Scheduling/shift cycles
- Access to health care
- Employer/industry culture
- Potential exposure to harmful substances
- Quality of rest/sleep
- Opportunities for exercise

Identification of Evidence Base

The evidence base identification pathway for Key Question 3C is summarized in Figure 9. Our searches identified a total of 249 articles that appeared to be relevant to this key question. Following application of the retrieval criteria for this question (Appendix B: Retrieval Criteria), 45 full-length articles were retrieved and read in full. Table 83 identifies 17 of the 45 retrieved articles that were found to meet the inclusion criteria (Appendix C: Inclusion Criteria) for this key question. Table D-1 of Appendix D lists the 28 articles that were retrieved, read in full, and then excluded. The table also provides justification for their exclusion.

Figure 9. Development of Evidence Base for Key Question 3C

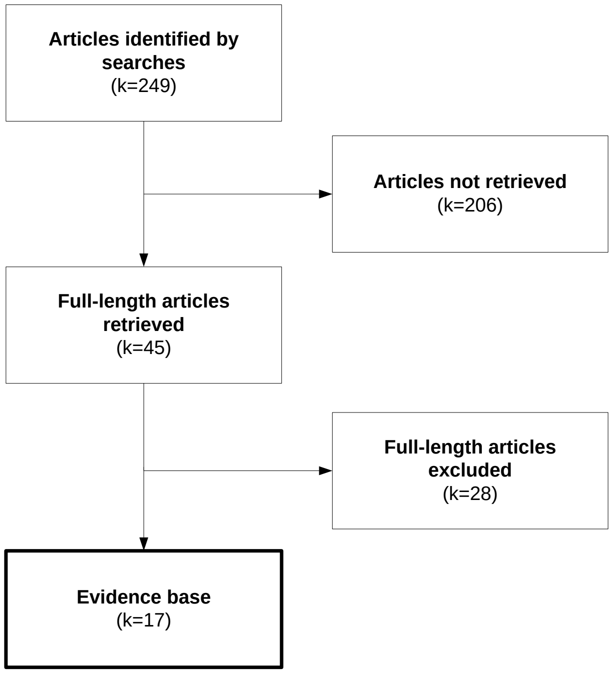


Table 83. Studies Addressing Specific Work Environment Characteristics - Key Question 3C

Reference	Year	Demographic Characteristics Reported								
		Control over Trips	Interactions with Passengers	Cabin Ergonomics	Scheduling/Shift Cycles	Access to Health Care	Employee/Industry Culture	Potential Exposure to Harmful Substances	Quality of Rest/Sleep	Opportunity for Exercise
Commercial Motor Vehicle Drivers – Truck										
Beilock[113]	2003		✓							
Chiu et al.[115]	2011							✓		
Chiu et al.[116]	2010							✓		
Crum et al.[119]*	2002	✓	✓		✓		✓		✓	
Davis et al.[120]	2007							✓		
Dinges & Maislin[80]	2006		✓		✓				✓	
Fine et al.[122]	2012								✓	
Fu et al.[123]				✓						
Layne et al.[130]	2009					✓				

Reference	Year	Demographic Characteristics Reported								
		Control over Trips	Interactions with Passengers	Cabin Ergonomics	Scheduling/Shift Cycles	Access to Health Care	Employee/Industry Culture	Potential Exposure to Harmful Substances	Quality of Rest/Sleep	Opportunity for Exercise
McCartt et al.[132]	2008		✓						✓	
Morrow & Crum[45]	2004				✓		✓		✓	
Reed & Cronin[134]	2003		✓			✓	✓			
Smith et al.[139]	2006							✓		
Solomon et al.[141]	2004		✓			✓			✓	
Stasko & Neale[142]	2007					✓				
Turner & Reed[143]	2011									✓
Commercial Motor Vehicle Drivers – Motorcoach/bus										
Crum et al.[119]*	2002	✓			✓		✓			
Escoto and French[121]					✓					
Howarth[126]	2002				✓				✓	
Sando et al.[138]	2010				✓				✓	
Total		**1***	**6**	**1**	**6***	**4**	**4***	**4**	**8**	**1**

*Crum et al., 2002, a single article, assessed both truck and coach drivers, and therefore, the total number of studies for an attribute may look like it's one number more than it should be.

Evidence Base Description

This subsection provides a brief description of the key attributes of the 17 studies that compose the evidence base for Key Question 3C. Here, we discuss applicable information relevant to the quality of the included studies and the generalizability of each study's findings to truck and motorcoach/bus drivers.

Characteristics of Included Studies

The primary characteristics of the 17 included studies that address Key Question 3C are presented in Table 28. Two primary study designs (cross-sectional and cohort) characterize the studies included in the evidence base for this key question. Although the included studies' assess different variables, their commonality is they provide data on one or more of the seven categories that distinguish demographic trends among truck and coach drivers.

Additional information about the studies, including location and scale of the studies (Table 27), risk of bias assessment (Table 29), and quality assessment (Table 30), can be found in the introduction of Key Question 3.

Findings

Seventeen studies met our inclusion criteria for Key Question 3C, which assesses the following factors of work environment:

- Control over trips
- Interactions with passengers (or team driving)
- Cabin ergonomics
- Scheduling/shift cycles
- Access to health care
- Employer/industry culture
- Potential exposure to harmful substances
- Quality of rest/sleep
- Opportunities for exercise

Overall, 15 studies focused on truck drivers and two on motorcoach/bus drivers. Each work environment attribute is described in turn below for truck and then motorcoach/bus drivers.

Control Over Trips

One included study[119] evaluated the topic of drivers' control over trips (see Table 57). Crum et al.[119], examined responses from three driver groups – two separate groups of truck drivers, and one group of coach drivers.

Truck Drivers

Crum et al.[119], which investigated scheduling practices of commercial drivers and their influence on driver fatigue, obtained data from 502 truck drivers (driver group 1) on the following indicators of control over trips:

- Regularity of route
- Freedom to choose route (flexibility)
- Longer than anticipated load times (for 30 percent or more of all loads)
- Finding a place to rest (also considered under "opportunities for rest")
- Schedule delays
- Number of stops per day

Of the drivers participating in this study, the findings for each of these indicators are described below (see also Table 92).

- 45.9 percent of drivers reported they drive the same route regularly; 54.1 percent reported driving a wide variety of routes.
- 84.4 percent of drivers reported high levels of flexibility over their routes.
- 52.6 percent of drivers reported that they wait longer than anticipated for 30 percent or more of their loads.
- 51.3 percent of drivers reported that they "never," "rarely," or "sometimes" have difficulty finding a place to rest compared with 48.7 percent who noted that they "frequently" or "always" have this problem (48.7 percent).
- 18.3 percent of drivers reported 0 to 90 percent of their work time was consumed by scheduling delays. The larger majority did not report this as a problem.
- 51.4 percent of drivers reported making one or fewer stops per day on average, and 48.6 percent reported making two or more. On average, 2.39 stops are made. Crum et al. also reported the average number of stops per day for a second group of 279 long-haul drivers (driver group 2). In this group, drivers reported making approximately 5 stops per day, on average.

Table 84. Truck Drivers' Control Over Trips

				Findings on Indicators of Control Over Trips, %					
Study	Year	Number of Drivers	Types of Driving (Long Distance, Local or Regional)	Route Regularity	Route Flexibility	Longer Than Anticipated Wait Time (ie, greater than 30% of loads)**	Have Difficulty Finding Place to Rest**	Schedule delays*	Two or More Stops Per Day (Mean) **
Crum et al.[119]	2002	Driver group 1 502	Long Distance	45.9	84.4	52.6	48.7	18.3	48.6 (2.39)
		Driver group 2 279	Long Distance	NR	NR	NR	NR	NR	(4.98)***

NR – Not reported
* Percent of day spent in traffic delays or waiting to make pick-up or delivery
** Reported as the a predictor for various fatigue outcome measures in this study
*** Indicated as average for both pick-ups and deliveries. Authors note that this sample (ie, driver group 2) was likely engaged in shorter runs requiring more frequent stops compared to group 1 which was sampled from truck stops.

Motorcoach/bus Drivers

Crum et al.[119] also assessed attributes of "trip control" in a sample of motormotorcoach/bus drivers (driver group 3). However, specific values for each of the indicators comprising trip control (described above for the truck driver part of the larger study) were not provided. Rather, survey responses of 122 motorcoach drivers were used to assess the effectiveness of a model for predicting fatigue-related incidents. However, in providing descriptive characteristics of the sample of motorcoach/bus driver participants, Crum et al., noted that these drivers reported an average of 4 stops per day. Summary data of the motorcoach/bus driver responses to other indicators or control over trips (eg, route regularity, flexibility, etc.) were not reported in the study.

Truck and Motorcoach/bus Driver Comparison on Control over Trips

Data retrieved from one included study provided summary data for a group of 502 long-haul truck drivers, which are described above (see Table 84). No comparable summary data were available for motorcoach/bus drivers, with the exception of the number of stops per day (one indicator of control over trips). Moreover, the 122 coach drivers for this study was relatively small. As a result, we are unable to make a comparison between truck and motorcoach/bus drivers with respective to control over trips.

Interactions with Passengers/Team Driving

Interactions with passengers are uniquely different for truck drivers compared with motorcoach/bus drivers. For truck drivers, our assessment looked at team driving patterns. For motorcoach/bus drivers a completely different host of attributes apply in considering their interactions with passengers, including their communications with passengers, pressures associated with carrying passengers, and a host of other factors.

Six truck drivers studies (Beilock et al., 2003[113]; Crum et al., 2002[119]; Dinges and Maislin, 2006[80]; McCartt et al., 2008[132]; Reed and Cronin, 2003[134]; and Solomon et al., 2004[141]) met the criteria for team driving (see Table 83). Only one study of motorcoach/bus drivers provided qualitative data on the unique characteristics related to the types of interactions of drivers with passengers. No quantitative data (eg, number of interactions, etc.) were provided related to this attribute for coach drivers.

Truck Drivers

The results of the six included studies, one of which included data from two independent samples of truck drivers (Crum et al.), are presented in Table 85. As seen in the table below, the range of truck drivers who always or generally drive alone is 65 to 91 percent (excluding the Reed and Cronin study which sampled only female drivers), with a mean of 86 percent. The range of drivers who generally or always drive with a co-driver was 1.5 to 20 percent, with a mean of 9 percent. The percent of drivers who sometimes drive with co-drivers ranged from 0 to 26.5 percent, with a mean of 7 percent. Note, because the pattern for team driving in the Reed and Cronin study, which consisted of only female drivers, was different from that seen in other studies, it was excluded from the calculations, although identified in Table 85.

Table 85. Percent of Truck Drivers who Drive Alone or With Co-Driver

Study	Year	Number of Drivers	Types of Driving (Long-haul, Local or Regional)	Findings on Truck Drivers who Drive Alone or With Co-Driver, %					
				Driving Alone		Co-Driver		Team Driving Sometimes	
				N	%	N	%	N	%
Beilock[113]	2003	1,624	Long distance	1,478	91	146	9	0	0

Study	Year	Number of Drivers	Types of Driving (Long-haul, Local or Regional)	Findings on Truck Drivers who Drive Alone or With Co-Driver, %					
				Driving Alone		Co-Driver		Team Driving Sometimes	
				N	%	N	%	N	%
Crum et al.[119]*	2002	502	Long distance Driver Group 1	NR	65	NR	18	NR	17
	2002	279	Long distance Driver Group 2	NR	72	NR	1.5	NR	26.5
Dinges & Maislin[80]	2006	2,051	All types	1,853	90	78	3.5	120	6.4
McCartt et al.[132]	2008	354	Long distance	NR	NR	32	8	NR	NR
		338	Long distance	NR	NR	68	20	NR	NR
		356	Long distance	NR	NR	29	8	NR	NR
		350	Long distance	NR	NR	67	19	NR	NR
		236	Long distance	NR	NR	21	9	NR	NR
		287	Long distance	NR	NR	57	20	NR	NR
Reed & Cronin[134]**	2003	284	Long distance	57	20	159	56	68	23.7
Solomon et al.[141]	2004	521	Long distance	415	80	59	11	44	9
Total (Mean)		**6,898**	**--**	**4,273$^{\beta}$**	**(86$^{\beta}$)**	**652$^{\beta}$**	**(9$^{\beta}$)**	**323$^{\beta}$**	**(7$^{\beta}$)**

NR – Not reported
* Study did not provide number of participants who responded to attribute, only the percentage of participants. For the purpose of drawing an overall mean of all studies, a number was configured based off the percentage and total number of participants.
**All female drivers. Excluded from mean. Many reported their co-driver was their partner or spouse.
β Adjusted for missing data

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for interactions with passengers. However, the majority of motorcoach/bus drivers can be expected to interact with passengers and attend to their requests, needs, and safety throughout the workday.

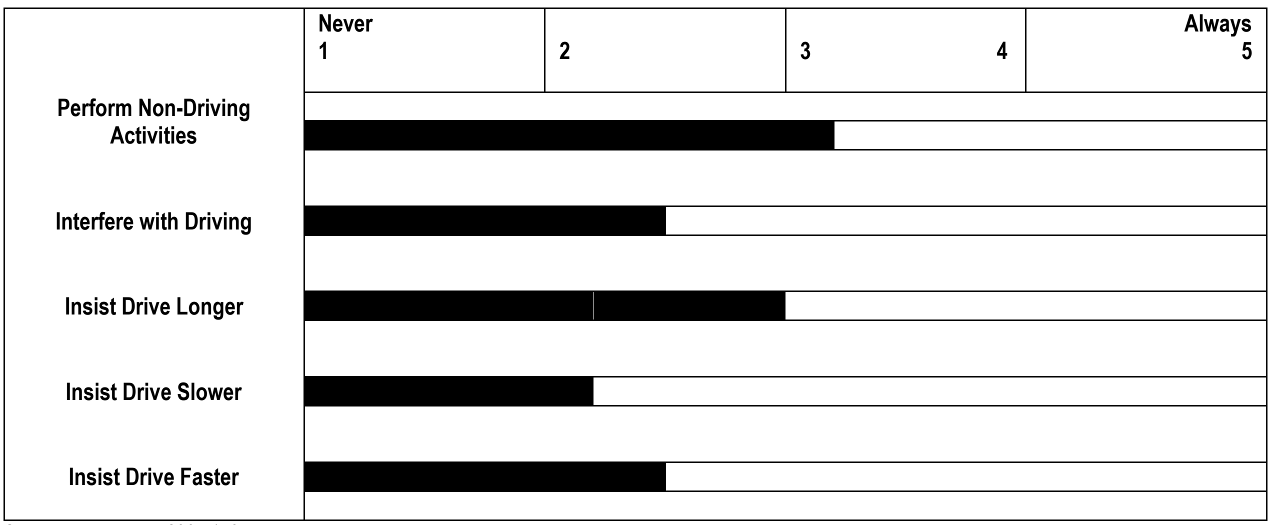
Issues that may be more pertinent to motorcoach/bus drivers in terms of fatigue and/or distractions relate to the driver/passenger interface. As noted in the Crum et al. study, the driving area is not physically isolated from the passenger area, and may result in passenger conversation with drivers and driver distraction because of passenger activities. Additionally, drivers must tend to passengers' needs (eg, luggage), take tickets, and perform other tasks, adding to their work time and possibly increasing stress. However, having numerous people observing a motorcoach/bus driver's behavior may produce an incentive for more diligence and professionalism on the part of a driver, but this may also cause stress and fatigue for drivers. Indeed, the presence of passengers in the vehicle was identified in focus groups (during the formative research phase of the Crum et al. study) as a unique aspect of motorcoach/bus driving that can lead to driver stress and fatigue.

In Brock et al., 2005[153], a motorcoach synthesis that surveyed 1) representatives of motorcoach companies and 2) research scientists and other transportation specialists, found that motorcoach drivers' non-driving interactions with passengers to cause serious problems leading to fatigue. Loading and unloading luggage, passenger assistance, and ticket handling were all identified as both fatigue inducing and limiting opportunities for rest.

Although Brock et al. did not meet the inclusion criteria for this key question (see Appendix D), the study is worth noting because it offers insight on issues motorcoach drivers face with passengers and, in general, there is a lack of data on this subject. Both survey groups identified passengers as a cause of stress for drivers, but neither group was specific about what passengers do that is stressful. Instances of passengers specifically giving driving directions (eg, drive faster) to motorcoach drivers were cited as rare or an event that occurs only sometimes. Passenger requests to ignore the HOS regulations were mentioned only slightly more frequently.

Figure 10 shows the survey response distribution for the series of questions probing passengers' interactions with drivers.

Figure 10. Frequency of Requests that Passengers Make of Motorcoach Drivers (Brock et al., 2005)



Source: Brock et al., 2005[153]

Truck and Motorcoach/bus Driver Comparison - Interactions with Passengers

Our comparison of truck and motorcoach/bus driver interactions with passengers is not directly comparable. For truck drivers, our assessment related to the drivers who drive with a co-driver or as part of a team (see Table 85). As the data from multiple studies reflect, the majority of long-haul drivers generally do not drive with a co-driver (65 to 91 percent of truck drivers in six independent samples of drivers, with a mean of 86 percent). We were unable to identify quantitative data regarding bus driver interactions with passengers. One included study described qualitative aspects of motorcoach/bus driver interactions with passengers, which encompassed responding to passengers' questions, addressing specific needs (eg, luggage), taking tickets, and a host of other tasks while transporting passengers from one location to another.

While there was no specific data available for this comparison, coach driver interactions with passengers is clearly an attribute that is largely different between truck and motorcoach/bus drivers.

Cabin Ergonomics

One truck driver study (Fu et al., 2010[123]) met the inclusion criteria for this attribute. We did not find any motorcoach/bus driver studies that met the inclusion criteria for cabin ergonomics; however, Crum et al. mentions differences in seating between truck and coach drivers.

Truck Drivers

This section comprises three parts in which one or more studies evaluate truck cabs': 1) noise level, 2) whole body vibration, and 3) air quality.

Fu et al., 2010, evaluated all three categories inside the cabins of 22 latest-model long-haul freight trucks from four different manufacturers. Measurements were conducted while the trucks were parked with the engines idling at a truck-stop rest area and during an actual on-road driving episode that included interstates and state highways, over moderately steep and relatively flat terrains. The parked engine-idling test involved measuring in-cab air quality under several engine and heating, ventilation, and air-conditioning (HVAC) modes of operation.

Noise Level

Noise data were collected continuously during the on-road driving test using an integrating, averaging sound-level meter. Overall, noise levels during on-road driving were well-below the Occupational Safety and Health Administration (OSHA) permissible exposure level (PEL) – 90 decibels (dBA) – and/or the National Institute for Occupational Safety and Health (NIOSH) recommended value – 85 dBA for an 8-hour work day.[5]

The noise levels also did not exceed the Action Level (AL), which is 50 percent of the maximum PEL. When the current 11-hour driving time limit is considered for the worst case truck, the estimated dose percent was still not exceeded for the AL. This study showed overall noise levels to be somewhat lower than those reported in the literature from other studies, which showed noise levels greater than the AL.

Table 86 provides mean noise measurements for all trucks and those from each manufacturer.

[5] According to Federal Motor Carrier Safety Regulations (49 CFR part 393.94) the interior sound level at the driver's seating position must not exceed 90 dBA, as measured when the truck is parked with all doors, windows, and vents closed; all power-operated accessories turned off; and, with the transmission in neutral, the engine is accelerated to—and stabilized at—either its maximum governed engine speed if it is equipped with an engine governor, or its maximum rated horsepower. The regulation does not specify a maximum time-weighted-average dBA level for an 8-h work day, which was the standard used in this study.

Table 86. Mean On-Road In-Cab Noise Levels Per Truck Manufacturer, and OSHA and ISO Integrator Measurements

Tests	Manufacturer Mean Measurements*				All Trucks
	A (7 trucks)	B (4 trucks)	C (5 trucks)	D (6 trucks)	
Peak (dBC)	120.6	118.0	114.2	118.4	**118.1**
Min L_{Min} (dBA)	65.0	65.7	66.6	64.2	**65.3**
Max L_{Max} (dBA)	92.6	92.8	91.4	93.3	**92.5**
OSHA Dose (5)	2.4	0.5	0.4	0.7	**1.1**
OSHA Estimated Dose (%)**	6.8	1.2	1.1	2.0	**3.2**
OSHA L_{eq} (dBA)	70.0	53.8	57.4	58.9	**61.2**
OSHA 8-h TWA dBA***	62.5	46.0	49.8	51.0	**53.5**
ISO Dose (%)	7.8	4.3	4.6	4.6	**5.6**
ISO Estimated Dose (%)	22.1	12.7	13.3	13.7	**16.1**
ISO L_{eq} (dBA)	78.3	75.9	76.1	76.2	**76.8**
ISO 8-h TWA (dBA)	73.7	71.2	71.5	71.4	**72.1**

dBC – decibel using the C-filter weighting; dBA – decibel scale using the A-filtering weighting; ISO – International Organization for Standardization; L – sound level; L_{eq} – equivalent continuous sound level; L_{Min} – minimum recorded sound level; L_{Max} – maximum recorded sound level; Min – minutes; OSHA – Occupational Safety and Health Administration; TWA – time weighted average.
* The results presented in this table are the overall mean of all trucks tested.
**When the sound level, L, is constant over the entire work shift, the noise dose, D, in percent, is given by: D=100 C/T where C is the total length of the work day, in hours, and T is the reference duration corresponding to the measured sound level, L.
**TWA values are not referenced over an actual or total 8-hour work shift.

Whole-Body Vibration

The over-exposure levels of vibration that cause fatigue, decrease in proficiency, reduced comfort, or actual damage to muscles, organs, and nervous system are not currently known with certainty. Fu et al. evaluated seat vibration based on the International Organization for Standardization (ISO) guidelines[6] in up to 24 of the 27 trucks. Analysis of WBV from driver and passenger seats involved two instrument measurement systems and two assessment methodologies. Overall, results in all cases indicated that vibration from the seats was generally below the ISO and European Union (EU) exposure action level (EAV)[7]. Exposure limits were exceeded in a few trucks, but for the most part these were isolated and probably due to the poor condition of the roadway pavement.

Significant differences were found in WBV between truck manufacturers, and between interstate and state highway driving, with the higher WBV occurring on the rural highway. Fu et al. concluded that if the EAV is projected to the current 11-hour limit, just three or four vehicles

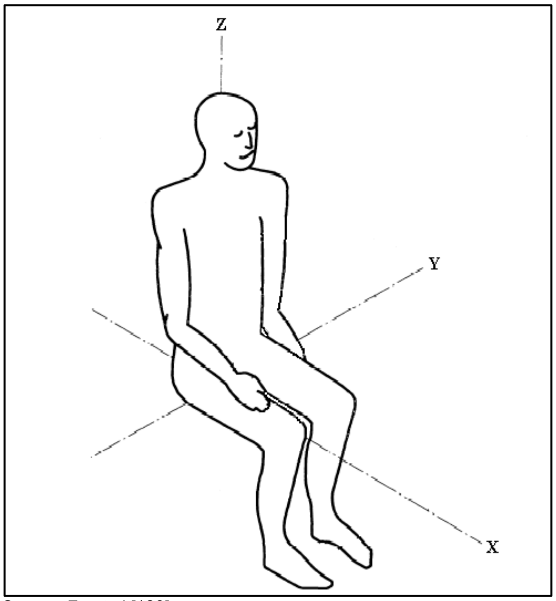
[6] The oldest standard for WBV is the ISO-2631-1. Occupational vibration standards are voluntary guidelines in the United States as OSHA has not established WBV standards for industry. ISO guidelines appear to be the most commonly referenced for WBV, and most of the other standards are identical to ISO-2631-1.

[7]The ISO and European Union (EU) recommend 0.5 m/s^2 as the EAV for an 8-hour day and 1.15 m/s^2 as the exposure limit value (ELV).

came close or were actually over this limit, but this occurred mostly in the y-axis, which is less serious than vibration in the z-axis, because the z-axis is the linear direction of the spinal column for a seated person (see Figure 11).

ISO's comfort index of the seats, in the majority of the trucks, fell within the "a little uncomfortable" region (see Box 3). This is the second best comfort indicator in the rating system; the best is "not uncomfortable." Fu et al. noted that few studies have been conducted in the United States on WBV from heavy-duty diesel truck seats.

Figure 11. Three-Dimensional Coordinate System for Human Body Seated in a Seated Position



Source: Fu et al.[123]
The x-, y- and z-axis are the three-dimensional coordinate system for the human body in a seated position. The direction of the x-axis is the orientation of back-to-front; rotation about the x-axis is called roll call. The direction of the y-axis is the orientation of right-to-left side; rotation about the y-axis is called pitch. The direction of the z-axis is the orientation of head-to-buttocks; rotation of the z-axis is called yaw.

Box 3. ISO 2631-1 Comfort Reactions to a Vibration Environment (Seating Position)

Vibration Magnitude (Σ)*	Likely Reaction
< 0.315 m/s²	Not uncomfortable
0.315 m/s² to 0.63 m/s²	A little uncomfortable
0.5 m/s² to 1 m/s²	Fairly uncomfortable
0.8 m/s² to 1.6 m/s²	Uncomfortable
1.25 m/s² to 2.5 m/s²	Very uncomfortable
> 2 m/s²	Extremely uncomfortable

*Sigma (Σ) – A single value of the three translational axes of acceleration (x, y, and z). On its own, Σ is used as relative value for the perception of comfort. In ISO 2631-1, the recommended correction factors for a seated person are $k_x = k_y = k_y = 1$. Since acceptable values for comfort depend on many factors, which can vary with each application, overall limits are not absolutely defined. However, the following ranges of values, listed above, are recommended in ISO 2631-1 to illustrate the likely reactions.

Table 87 provides the average vibration scores of all trucks' driver seats, as well as driver back rest and passenger seat cushion.

Table 87. Mean Vibration Values on All Trucks' Seat Cushions Per Roadway

Axis and Roadway	Mean of All Trucks: Comfort vs. Roadway						
	RMS Values Axis of Translation m/s^2				VDV Axis of Translation $m/s^{1.75}$		
	Driver Seat Cushion (23 Trucks)	Driver Seat Cushion (24 Trucks)	Driver Back Rest	Passenger Seat Cushion	Driver Seat Cushion	Driver Back Rest	Passenger Seat Cushion
X-axis I-40	0.25	0.19	.24	.05	3.67	4.12	3.26
X-axis US-27	0.28	0.23	.27	.22	4.86	4.34	3.70
X-axis I-75	0.28	0.22	.28	.22	3.8	4.35	3.62
Y-axis I-40	0.30	0.33	.24	.23	5.17	3.28	3.06
Y-axis US-27	0.32	0.36	.23	.23	5.97	3.35	3.34
Y-axis I-75	0.32	0.33	.25	.23	5.01	3.57	3.29
Z-axis I-40	0.31	0.27	.29	.28	5.35	5.77	5.80
Z-axis US-27	0.35	0.28	.31	.30	5.96	6.14	6.33
Z-axis I-75	0.35	0.30	.33	.32	5.98	6.52	6.83
Σ I-40	**0.42**	**0.39**	**.38**	**.41**	**N/A**	**N/A**	**N/A**
Σ US-27	**0.47**	**0.43**	**.40**	**.44**	**N/A**	**N/A**	**N/A**
Σ I-75	**0.47**	**0.42**	**.42**	**.46**	**N/A**	**N/A**	**N/A**

N/A – Not applicable; RMS – root square mean; VDV – vibration dose value; Σ – Greek letter sigma for summation symbol or comfort index

Air Quality

Fu et al. measured in-cab air quality with emission analyzers for carbon monoxide (CO), oxides of nitrogen (NO_X), and particulate matter less than 2.5-µm in aerodynamic diameter ($PM_{2.5}$) in 27 trucks during on-road tests and while parked. The tests were performed under several engine and heating, ventilation, and air-conditioning (HVAC) modes of operation.

For the on-road tests, Fu et al. found the in-cab concentrations of the three air pollutants to be much lower than the concentrations measured during the parked-idling tests. However, while driving on the interstate, the inside concentrations were slightly higher relative to the concentrations measured while driving on the state highway. This condition is thought to be caused by the higher vehicle densities normally present on the interstate – a larger number of vehicles producing a greater quantity of pollutants that enter trucks through their HVAC systems. These results suggest there is less chance for the truck's exhaust to self-pollute the cab while the truck is driven than while it is parked and idling, and that the highway environment, rather than the truck itself, is the primary cause of the truck driver's in-cab exposure to air pollutants.

Average CO, NO_X, and $PM_{2.5}$ concentrations during parked-idling were approximately 1.5, 7.1, and 3.0 times greater than the on-road tests, respectively. Despite the difference, concentrations of CO, NO_X and $PM_{2.5}$ were relatively low inside the cab when the truck engine and the HVAC system were in off modes. Highest CO and NO_X concentrations occurred during engine-on and

HVAC in recirculation modes. High $PM_{2.5}$ concentrations occurred during engine-on and HVAC in fresh-air mode and during engine-on and fan-off modes.

Fu et al., which noted its results were in line with a similar study, concluded that long-haul trucks have a tendency to self-pollute the cab during extended periods of parked-idling conditions. This happens when the vehicle's own exhaust enters the cab. This and the close proximity of other trucks idling at the same time in the truck-stop rest areas create conditions for exhaust to enter the cab through the HVAC system or naturally from air infiltration around window and door seals and other areas.

The average 15-minute concentrations from the 27 trucks for CO, NO_X, and $PM_{2.5}$ and the ratio of NO to NO_X are shown in Table 88 for the three roadways or routes driven during the on-road tests.

Table 88. Overall Average 15-Minute Concentrations from On-Road Test

Road Type	CO (ppb)	NO_X (ppb)	NO/NO_X	$PM_{2.5}$ OPC (µg/m³)	$PM_{2.5}$ DRam (µg/m³)
Interstate (I-40)	414	109	0.74	9	12
Rural Highway (US-27)	285	39	0.52	7	12
Interstate (I-75)	362	96	0.65	7	13

CO – carbon monoxide; Dram – DataRam; NO_X – oxides of nitrogen; OPC – optical particle counter; $PM_{2.5}$ – particulate matter less than 2.5-µm in aerodynamic diameter; ppb – parts per billion by volume; µg/m3 – microgram per cubic meter

Average 1-hour concentrations for CO, NO_X, and $PM_{2.5}$ and the ratio of NO to NO_X are shown in Table 89 for the five truck engine/HVAC modes of operation.

Table 89. Overall Average 1-Hour Concentrations from Parked-Idling Test

Truck Engine	HVAC System	Sample Location	CO (ppb)	NO/NO_X (ppb)	NO/NO_X	$PM_{2.5}$ OPC (µg/m³)	$PM_{2.5}$ DRam (µg/m³)
Off	Fan Off	In-cab	396	120	0.73	7	14
Off	Fan Off	Outside	295	119	0.61	13	27
On	Fan Off	In-cab	508	624	0.85	19	48
On	Fresh Air	In-cab	472	466	0.81	22	51
On	Recirculation	In-cab	585	643	0.85	9	28

CO – carbon monoxide; DRam – DataRam; HVAC – heating, ventilation, and air-conditioning; NO_X – oxides of nitrogen; OPC – optical particle counter; $PM_{2.5}$ – particulate matter less than 2.5-µm in aerodynamic diameter; ppb – parts per billion by volume; µg/m3 – microgram per cubic meter

Motorcoach/bus Drivers

Although Crum et al. did not provide quantitative descriptions of cabin ergonomics, it provided qualitative descriptions of seating conditions, reporting that motormotorcoach/bus seats do not accommodate comfortable positions for quality rest or sleep, and motorcoaches do not easily accommodate acceptable "sleeper berth" areas for drivers. It was noted, however, that for most charter and tour trips, drivers almost always sleep in hotel beds.

Truck and Motorcoach/bus Driver Comparison on Cabin Ergonomics

Data retrieved from the one included truck study reveals of 22 to 27 new long-haul freight trucks from four different manufacturers:

- Noise levels during the on-road driving were well below the Occupational Safety and Health Administration (OSHA) permissible exposure level (PEL) – 90 decibels (dBA) – and/or the National Institute for Occupational Safety and Health (NIOSH) recommended value – 85 dBA for an 8-hour work day.
- Overall, vibration from all seats was generally below the ISO and European Union (EU) exposure action level (EAV)[8]. Exposure limits were exceeded in a few trucks, but for the most part these were isolated and probably due to poor condition of the roadway pavement.
- For the on-road tests, in-cab concentrations of air pollutants were much lower than concentrations measured during the parked-idling tests. Trucks have a tendency to self-pollute the cab during extended periods of parked-idling conditions because the vehicle's own exhaust enters the cab.

A paucity of data makes it difficult to ascertain the accuracy of these findings. Furthermore, no motorcoach/bus studies met the inclusion for this attribute.

Scheduling/Shift Cycles

Two truck driver studies (Dinges and Maislin, 2006[80]; and Morrow and Crum, 2004[45]), three bus driver studies(Escoto and French, 2012[121]; Howarth, 2002[126]; and Sando et al., 2010[138]), and one study (Crum et al., 2002[119]) addressing truck and coach drivers met the inclusion criteria for scheduling and shift cycles (see Table 83).

Truck Drivers

This section comprises three parts in which one or more studies evaluated: 1) consistency of drivers' scheduling, 2) percentage of drivers who work split shifts, and 3) prevalence of drivers who work at night.

Consistency of Scheduling

Crum et al., Dinges and Maislin, and Morrow and Crum found approximately 46 percent of truck drivers' start and stop their shifts at the same time every day. About 22 percent of drivers rarely have regular daily shifts, and nearly 38 percent sometimes do (see Table 90).

[8]The ISO and European Union (EU) recommend 0.5 m/s^2 as the EAV for an 8-hour day and 1.15 m/s^2 as the exposure limit value (ELV).

Table 90. Consistency of Truck Drivers' Schedules

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Start and Stop Work at Same Time Each Day					
				Always or Most of Time		Sometimes		Rarely or Never	
				N	%	N	%	N	%
Crum et al.[119]	2002	502	Long distance	NR	61.2	NR	NR	NR	38.8
Dinges & Maislin[80]	2006	2,219	All types	907	46	910	37.7	402	16.3
Morrow & Crum[45]	2004	116	All types	86	74	NR	NR	30	26
Total (Mean)		**2,837**	**--**	**1,300**	**(45.82)**	**910**	**(37.7β)**	**627**	**(22.10)**

NR – Not reported
* Study did not provide number of participants who responded to attribute, only the percentage of participants. For the purpose of drawing an overall mean of all studies, a number was configured based on the percentage and total number of participants.
β – Adjusted for missing data

Night Shift

Dinges and Maislin evaluated the number of bus drivers who work night shifts, finding 59 percent of drivers work nights and 41 percent work days (see Table 91). Crum et al. found similar findings, with 54.3 percent reporting they drove between midnight and 6 a.m.; however, the vast majority of drivers reported driving in multiple time zones. Crum et al. defined four times zones as 6 a.m. to noon, noon to 6 p.m., 6 p.m. to midnight, and midnight to 6 a.m. Few drivers reported (10.9) percent reported driving in only one time zone, and 25 percent reported driving in all four time zones.

Table 91. Percent of Truck Drivers that Drive Night Shifts

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Night Shifts			
				Night		Day	
				N	%	N	%
Crum et al.[119]*	2002	502	Long distance	NR	54.3	NR	45.7
Dinges & Maislin[80]	2006	2,280	All types	1,341	59.	939	41
Total (Mean)		**2,280**	**--**	**1,341**	**59**	**939**	**41**

NR – Not reported
* Day is considered to be three time zones defined by Crum et al.: 6 a.m. to noon, noon to 6 p.m., and 6 p.m. to midnight. Night time zone is considered midnight to 6 a.m.

Motorcoach/bus Drivers

Three bus driver studies, Escoto and French, Howarth, and Sando et al., and one coach driver study, Crum et al., evaluated one or more of the following: 1) consistency of drivers' scheduling, 2) prevalence of drivers who work split shifts, and 3) inverted duty shifts.

Consistency of Scheduling

Sando et al. found approximately 62 percent of bus drivers start and stop their shifts at the same time every day, although about 46 percent work different shifts (see Table 92).

Table 92. Consistency of Motorcoach/bus Drivers' Schedules

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Scheduling Consistency			
				Same Shift		Shifts Vary	
				N	%	N	%
Sando et al.[138]	2010	266	Local	165	62	122	46
Total (Mean)		**266**	**--**	**165**	**62**	**122**	**46**

Split Shifts

Escoto and French, Howarth, and Sando et al. assessed the prevalence of bus drivers who work split shifts, finding 44 percent of bus drivers work split shifts and 64 percent work straight shifts, on average (see Table 93). A split shift is defined as separate work periods within a day, each less than seven hours and separated by more than one hour away from work.

Table 93. Variability of Motorcoach/bus Drivers' Schedules

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Split Shifts			
				Split Shift		Straight Shift	
				N	%	N	%
Escoto and French[121]	2012	750	Local	259	35	491	65
Howarth[126]	2002	102	NR	72	71	30	29
Sando et al.[138]	2010	266	Local	165	62	101	38
Total (Mean)		**1,119**	**--**	**496**	**(44)**	**623**	**(56)**

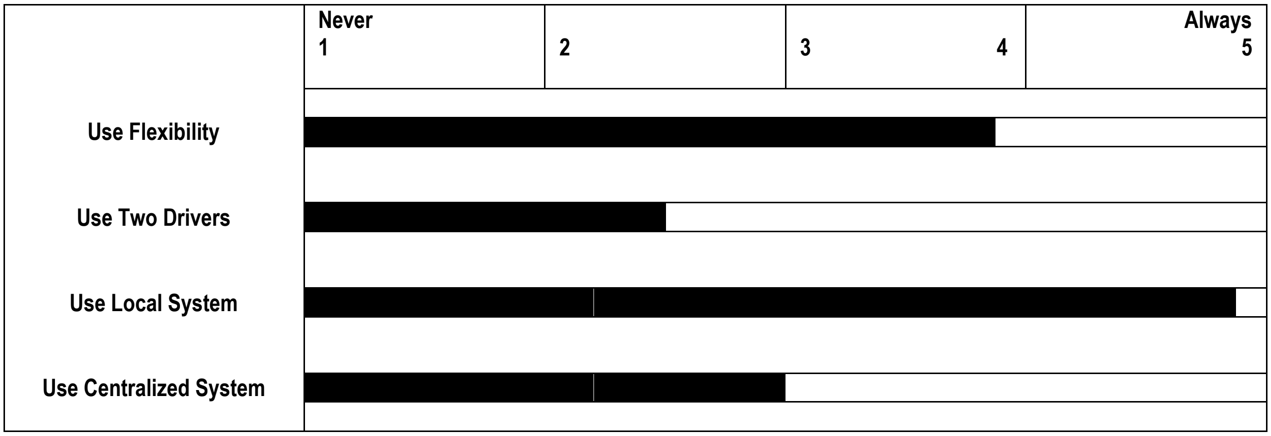
Inverted Duty Shifts

Crum et al. assessed the extent to which 122 coach drivers reported experiencing inverted schedules, which is defined as occurring "when a driver drives (or is on-duty) during a certain time period of day, and is off-duty during the same period the next day, with variable lengths of on-duty and off-duty periods during this cycle."

This was measured by a single survey item that asked participants to rate the extent to which they experienced inverted duty shifts using a scale of 1 (to a very little extent) to 7 (to a very large extent). Drivers reported this was experienced to some extent, with a mean response of 4.34.

Although not included in this key question (see Excluded Articles in Appendix D), it is worth noting Brock et al., 2005[153], a motorcoach synthesis that surveyed 1) representatives/managers of motorcoach companies and 2) research scientists and other transportation specialists. The study found that motorcoach companies are typically flexible with scheduling. Figure 12 shows survey response distribution for several factors regarding scheduling.

Figure 12. Industry Representatives' Perceptions of How Often Their Companies Perform Activities (Brock et al., 2005)



Source: Brock et al., 2005[153]

Truck and Motorcoach/bus Driver Comparison on Scheduling/Shift Cycles

Data retrieved from the six included studies reveal:

- Bus drivers (62 percent) appear to have more consistent scheduling than truck drivers (46 percent).
- The majority of bus drivers work (56 percent) straight shifts, and less than half (44 percent) work split shifts. Data to assess coach drivers on this attribute was not available.
- On a scale of 1 (to a very little extent) to 7 (to a very large extent), motorcoach drivers reported having inverted schedule to some extent, with a mean response of 4.34.

A paucity of data makes it difficult to ascertain the accuracy of these findings.

Access to Health Care

Four truck driver studies (Layne et al., 2009[130]; Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) met the inclusion criteria for access to health care (see Table 83). No studies met the inclusion criteria for motorcoach/bus drivers.

Truck Drivers

The findings of four studies assessing truck drivers' access to health care showed (see Table 94):

- Approximately 62 percent of truck drivers have a regular care provider.
- More than 1 in 4 truck drivers do not have health insurance.
- About 38 percent of truck drivers get insurance through their employers, while 12 percent have insurance through their spouse and 17 percent provide their own.

Table 94. Percent of Truck Drivers Who Have Health Care Access and Insurance

Reference	Year	No. of Drivers	Types of driving (Long distance, Local or Regional)	Health Care Access: Has Regular Care Provider		Source of Health Insurance*									
						No insurance		Via Employer		Via Spouse		Provides Own		Other	
				N	%	N	%	N	%	N	%	N	%	N	%
Layne et al.[130]	**2009**	50	Long distance	31	62	14	28	NR	NR	NR	NR	NR	NR	NR	NR
Reed & Cronin[134]	**2003**	284*	Long distance	221	77.8	56	20.6	73	26.8	48	17.6	74	27.2	21	7.7
Solomon et al.[141]	**2004**	531	Local	281	53	158	29.8	231	43.5	47	8.8	66	12.4	29	5.5
Stasko & Neale[142]	**2007**	30	Long distance	21	70	8	26.7	NR	NR	NR	NR	NR	NR	NR	NR
Total (Mean)		**895**		**554**	**(61.9)**	**236**	**(26.7)**	**304**	**(37.9[β])**	**95**	**(11.8[β])**	**140**	**(17.4[β])**	**50**	**(9.9[β])**

NR – Not reported

*Only 272 drivers reported their sources of health insurance

β Adjusted for missing data

Motorcoach/bus Drivers

No studies met the inclusion criteria for motorcoach/bus drivers on access to health care.

Truck and Motorcoach/bus Driver Comparison on Access to Health Care

The findings of four studies assessing truck drivers' access to health care showed (see Table 94):

- Approximately 62 percent of truck drivers have a regular care provider.
- More than 1 in 4 truck drivers do not have health insurance.
- About 38 percent of truck drivers get insurance through their employers, while 12 percent have insurance through their spouse and 17 percent provide their own.

The results of these studies could be misleading as there is a paucity of data and the sample sizes are small. No motorcoach/bus driver studies met the inclusion criteria for access to health care.

Employer/Industry Culture

Two included truck driver studies (Morrow and Crum, 2004[45]; and Reed and Cronin, 2003[134]) and one study that addresses both truck and coach drivers (Crum et al., 2002[119]) address pressures put on both truck and bus drivers, such as completing routes on time. Additionally, Crum et al. evaluates the pressure drivers feel by dispatchers, as well as pressure put upon dispatchers by their companies. Penalties and rewards of drivers are also assessed.

Truck Drivers

Three studies assess dispatcher pressure placed upon truck drivers. The first two studies cited in this section, Morrow and Crum and Reed and Cronin, offer quick snapshots of data while Crum et al. looks deeper at dispatcher pressure, including the pressures faced by dispatchers. Furthermore, Crum et al. includes data on penalties and rewards drivers receive for late and on-time loads/arrivals.

Dispatcher Pressure

Morrow and Crum surveyed 116 drivers from companies that were considered top-, average-, and low-performing safety firms, assessing the extent to which drivers felt dispatchers pressured them to continue driving when tired. On a scale from 1 to 7 (7 meaning a lot of pressure), drivers felt pressured by a mean number of 2.38 on the scale.

Reed and Cronin, which administered surveys to female drivers at a truck show, found 57 percent of 284 participants felt pressured at least several times a month to complete their loads more quickly.

Crum et al., which surveyed 279 truck drivers and representatives from 374 trucking companies, evaluated the pressure put on drivers by dispatchers and pressure put on dispatchers by their companies. Using a scale from 1 to 7 (7 meaning a lot of pressure), truck drivers were gauged on the pressure they feel to bend rules; and dispatchers were gauged on the pressure they feel to dispatch loads and ask drivers to overlook rest. The results showed (see Table 95)[9]:

- The mean response for truck drivers to bend rules was 3.98, placing it near the middle of the 1 to 7 range. With a standard deviation of 2.11, this attribute exhibited wide variation. Bending a safety rule was generally unrelated to other carrier economic indicators, except dispatcher pressure.
- The mean responses for the pressure dispatchers feel to dispatch loads and ask drivers to overlook rest were 2.08 and 2.12, respectively. The relatively low mean and small standard deviations of 1.61 and 1.42, respectively, suggest that pressure on dispatchers for these two attributes is not a widespread problem, but variable enough to merit further inquiry.

Table 95. Truck/Dispatcher Driver Response Rates on Pressure (Crum et al., 2002)

Variable	Response options 1 (to a very little extent) to 7 (to a very large extent)	
	Mean	SD
Pressure to bend rules (drivers' perceptions)	3.98	2.11
Pressure to dispatch loads (dispatchers' perceptions)	2.08	1.61
Pressure to ask drivers to overlook rest (dispatchers' perceptions)	2.12	1.42

SD – Standard Deviation

Penalties and Rewards

Crum et al. also asked the drivers the extent to which they are penalized for late deliveries. Penalties could include:

1. Verbal criticism from dispatchers
2. Pay reduction or fines
3. Loss of potential bonus money
4. Suspension from work
5. Employment termination
6. Assigning less desirable loads in the future.

The responses to these items were summed, with higher score indicating more penalties. On a scale from 1 to 7 (7 meaning a lot of pressure), drivers felt pressure by a mean number of 1.37 on the scale, suggesting relatively few companies have penalties for late deliveries. In turn, 86.1 percent of trucking company representatives reported they did not offer rewards to drivers for on-time deliveries. Despite those results, using the same scale above, drivers felt their companies rewarded them for safe driving by a mean number of 6.97 (see Table 96).

[9] Crum et al. provides a number of descriptive statistics for variables throughout its report, but not all could be used for this report due to descriptions of its various scales/scoring systems not being available in the main text. Although descriptions are provided in Appendix F, the appendix was not included in the main document.

Table 96. Truck Driver Response Rates for Driving Penalties/Rewards (Crum et al., 2002)

Variable	Response options 1 (to a very little extent) to 7 (to a very large extent)	
	Mean	SD
Personal motivations to continue driving when tired	6.59	3.48
Drivers compensated for on-time deliveries	.14	.35
Drivers penalized for late deliveries	1.37	1.66
Drivers rewarded for safe driving	6.97	4.43
Personal pride in on-time deliveries	6.44	1.02

Motorcoach/bus Drivers

One coach driver study (Crum et al., 2002[119]) assessed two key subjects: dispatcher pressure on drivers and company pressure on dispatchers, and 2) penalties for drivers arriving late and rewards for arriving on time. No other studies met the inclusion criteria for this driver group. Crum et al. assessed 122 motorcoach drivers and representatives from 66 motorcoach companies.

Dispatcher Pressure

Crum et al. evaluated the pressure put on drivers by dispatchers and pressure put on dispatchers by their companies. Using a scale from 1 to 7 (7 meaning a lot of pressure), coach drivers were gauged on the pressure they feel to bend rules; and dispatchers were gauged on the pressure they feel to dispatch loads and ask drivers to overlook rest. Results showed (see Table 97)[10]:

- The mean response for coach drivers to bend rules to be 3.13, placing it near the middle of the 1 to 7 range. With a standard deviation of 2.19, this attribute exhibited wide variation. Bending a safety rule was generally unrelated to other carrier economic indicators, except dispatcher pressure.
- The mean responses for the pressure dispatchers feel to dispatch loads and ask drivers to overlook rest were 2.56 and 1.59, respectively. The relatively low mean and small standard deviations of 1.52 and 1.37, respectively, suggest that pressure on dispatchers for these two attributes is not a widespread problem, but variable enough to merit further inquiry.

Table 97. Coach/Dispatcher Driver Response Rates on Pressure (Crum et al., 2002)

Variable	Response options 1 (to a very little extent) to 7 (to a very large extent)	
	Mean	SD
Pressure to bend rules (drivers' perceptions)	3.13	2.19
Pressure to dispatch loads (dispatchers' perceptions)	2.56	1.52
Pressure to ask drivers to overlook rest (dispatchers' perceptions)	1.59	1.37

[10] Crum et al. provides a number of descriptive statistics for variables throughout its report, but not all could be used for this report due to descriptions of its various scales/scoring systems not being available in the main text. Although descriptions are provided in Appendix F, the appendix was not included in the main document.

Penalties and Rewards

Crum et al. asked coach drivers to what extent they believe they are penalized for late arrivals. Penalties could include:

1. Verbal criticism from dispatchers
2. Pay reduction or fines
3. Loss of potential bonus money
4. Suspension from work
5. Employment termination
6. Assigning less desirable trips in the future.

The responses to these items were summed, with higher score indicating more penalties. On a scale from 1 to 7 (7 meaning a lot of pressure), drivers felt pressure by a mean number of 1.08 on the scale, suggesting relatively few companies have penalties for late arrivals. In turn, a mean number of 0 trucking company representative reported they offered rewards to drivers for on-time arrivals. Despite these results, using the same scale above, drivers felt rewarded for safe deliveries, showing a mean number of 6.92.

Table 98. Coach Driver Response Rates for Driving Penalties/Rewards (Crum et al., 2002)

Variable	Response options 1 (to a very little extent) to 7 (to a very large extent)	
	Mean	SD
Personal motivation drive for income	2.63	1.92
Drivers compensated for on-time deliveries	.00	.27
Drivers penalized for late arrival	1.08	1.66
Drivers rewarded for safe driving	6.92	4.35
Personal pride in on-time deliveries	5.92	1.39

Truck and Motorcoach/bus Driver Comparison on Employer/Industry Culture

Data retrieved from three included studies reveal:

- **Morrow and Crum:** On a scale from 1 to 7 (7 meaning a lot of pressure), drivers feel pressured to continue driving when tired by a mean number of 2.38 on the scale.
- **Reed and Cronin:** 57 percent of drivers feel pressured, at least several times a month, to complete their loads more quickly.
- **Crum et al (see Table 99):** Both truck and coach drivers feel pressure to bend driving rules because of dispatchers. On a scale of 1 to 7 (7 meaning a lot of pressure), both driver groups scored in the 3 range, with truck drivers reporting a mean number of 3.98 and coach drivers a 3.13. A significant difference was found between truck and coach drivers on personal motivations to continue driving when tired. Truck drivers reported a mean score of 6.59 on the 1 to 7 scale, meaning to a very large extent, whereas coach drivers reported a mean score of 2.63, meaning to a lesser extent.

The results of these studies could be misleading as there is a paucity of data and the sample sizes are small.

Table 99. Comparison of Dispatcher Pressure and Rewards and Penalties for Truck and Coach Drivers

Variable	Response options 1 (to a very little extent) to 7 (to a very large extent)			
	Truck Drivers		Coach Drivers	
	Mean	SD	Mean	SD
Dispatcher Pressure				
Pressure to bend rules (drivers' perceptions)	3.98	2.11	3.13	2.19
Pressure to dispatch loads (dispatchers' perceptions)	2.08	1.61	2.56	1.52
Pressure to ask drivers to overlook rest (dispatchers' perceptions)	2.12	1.42	1.59	1.37
Penalties and Rewards				
Personal motivations to continue driving when tired	6.59 ↑**Significant**	3.48 ↑**Significant**	2.63 ↓**Significant**	1.92 ↓**Significant**
Drivers compensated for on-time deliveries	.14	.35	.00	.27
Drivers penalized for late deliveries	1.37	1.66	1.08	1.66
Drivers rewarded for safe driving	6.97	4.43	6.92	4.35
Personal pride in on-time deliveries	6.44	1.02	5.92	1.39

Potential to Exposure of Harmful Substances

Four included studies (Chiu et al., 2011[115]; Chiu et al., 2010[116]; Davis et al., 2007[120]; and Smith et al., 2006[139]) met the inclusion criteria for evaluating truck drivers' potential exposure to harmful substances in their air (see Table 83). No studies met the inclusion criteria for motorcoach/bus drivers.

Truck Drivers

Four truck driver studies assess harmful substances in three categories: (1) plasma continine, (2) vapor-phase nicotine, and (3) combustion particles.

Plasma Continine (Secondhand smoke measurement)

Chiu et al., 2011, evaluated levels of plasma continine and inflammatory markers in 97 nonsmoking drivers, finding about 50 percent of drivers were exposed to high continine levels, 45 percent to low levels, and 5 percent to levels that are below the limit of quantitation.

Vapor-Phase Nicotine

Chiu et al., 2010, evaluated vapor-phase nicotine in the breathing zone of 113 truck drivers, who were measured by personal monitors. Chiu found the interquartile range median (IQR) of vapor phase nicotine among 93 nonsmokers to be 0.87 (0 to 56.9). The IQR for 20 smokers was four times higher at 4.61 (1.44 to 51.2).

Combustion Particles

Davis et al. and Smith et al. evaluated exposure to the mass of particles less than 2.5 µm in diameter (PM), and elemental carbon (EC) and organic carbon (OC) in particles less than 1 µm in diameter (PM1).

The mean elemental carbon (in µ/gm3) was (see Table 100):

- Arithmetic mean: 1.46, SD = 0.79
- Geometric mean: 1.20, SD = 3.30

The mean organic carbon (in µ/gm3) was:

- Arithmetic mean: 1.46, SD = 0.79
- Geometric mean: 1.20, SD = 3.30

The mean PM2.5 (in µ/gm3) was:

- Arithmetic mean: 52.6, SD = 327.7
- Geometric mean: 23.1, SD = 2.5

Table 100. Truck Drivers' Exposure to Combustion Substances

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Exposure to Combustion Substances											
				Elemental carbon (in µ/gm3)				Organic carbon (in µ/gm3)				PM2.5 (in µ/gm3)			
				Arith-metic mean	SD	Geo-metric mean	SD	Arith-metic mean	SD	Geo-metric mean	SD	Arith-metic mean	SD	Geo-metric mean	SD
Davis et al.[120]	2007	349	Long distance	1.4	0.80	1.1	2.3	21.30	17.10	18.0	1.7	52.6	327.7	23.1	2.5
Smith et al.[139]	2006	333	Long distance												
Non-smokers		173*		1.32	0.70	1.12	1.91	25.39	19.26	19.07	2.30	NR	NR	NR	NR
Smokers		78*		1.67	0.88	1.37	2.40	140.59	682.27	32.81	3.23	NR	NR	NR	NR
Mean		**341**	**--**	**1.46**	**0.79**	**1.20**	**3.30**	**62.43**	**239.5**	**23.29**	**2.41**	**NR**	**NR**	**NR**	**NR**

NR – Not reported
* Percent of day spent in traffic delays

Motorcoach/bus drivers

No studies met the inclusion criteria on motorcoach/bus drivers' time exposure to harmful substances.

Truck and Motorcoach/bus Driver Comparative on Exposure to Harmful Substances

Data retrieved from four included studies reveal:

- 50 percent of truck drivers are exposed to high continine levels, 45 percent to low levels, and 5 percent to levels that are below the limit of quantitation.
- The interquartile range median (IQR) of vapor phase nicotine for nonsmokers was 0.87 (0 to 56.9). For smokers, it was 4.61 (1.44 to 51.2).
- The mean elemental carbon (in µ/gm3) was:
    - Arithmetic mean: 1.46, SD = 0.79
    - Geometric mean: 1.20, SD = 3.30
- They found the mean organic carbon (in µ/gm3) to be:
    - Arithmetic mean: 1.46, SD = 0.79
    - Geometric mean: 1.20, SD = 3.30
- They found the mean PM2.5 (in µ/gm3) to be:
    - Arithmetic mean: 52.6, SD = 327.7
    - Geometric mean: 23.1, SD = 2.5

The results of these studies could be misleading as there is a paucity of data. No studies met the inclusion criteria for motorcoach/bus drivers' exposure to harmful substances.

Quality of Rest/Sleep

Six truck driver studies (Crum et al., 2002[119]; Dinges and Maislin, 2006[80]; Fine et al., 2012[122]; McCartt et al., 2008[132]; Morrow and Crum, 2004[45]; and Solomon et al., 2008[141]) and two bus studies (Howarth, 2002[126]; and Sando et al., 2010[138]) met the inclusion criteria for evaluating quality of rest/sleep (see Table 83).

Truck Drivers

This section comprises three parts, evaluating: 1) total sleep time, 2) uninterrupted sleep time, and 3) difficult sleeping.

Total Sleep Time

Dinges and Maislin and McCartt et al. assessed hours of sleep per day among truck drivers. Dinges and Maislin reported a mean sleep time of 6.94 hours a day. In McCartt's post 2004 rule change, 62 percent of drivers slept 8 hours or more. Only 38 percent slept less than eight hours, which is 11 percent more drivers than before the rule change (see Table 101).

Table 101. Total Sleep Time Among Truck Drivers

Study	Year	Number of Drivers		Types of Driving (Long distance, Local or Regional)	Findings on Number Hours of Daily Sleep N (%)			
					Mean Hours	< 8 Hours	8-9 Hours	> 9 Hours
Dinges & Maislin[80]	2006	2,280		All types	6.94	NR	NR	NR
McCartt et al.[132]*	2008	323 (PA: 2004)	Before 2004 rule	Long distance	NR	165 (51)	129 (40)	29 (9)
			After rule		NR	126 (39)	129 (40)	68 (21)
		319 (OR: 2004)	Before 2004 rule		NR	150 (47)	128 (40)	41 (13)
			After rule		NR	131 (41)	128 (40)	60 (19)
		216 (PA: 2005)			NR	78 (36)	88 (41)	50 (23)
		239 (OR: 2005)			NR	84 (35)	105 (44)	50 (21)
Total (Mean) [Before rule]**		**642**		**--**	**--**	**315 (49)**	**257 (40)**	**70 (11)**
Total (Mean)* [2004-2005]**		**1,097**		**--**	**--**	**419 (38)**	**450 (41)**	**228 (21)**

PA – Pennsylvania; OR - Oregon
**Mean findings for driving time before the Jan. 4,2004, hour-of-service rule change.
***Excludes findings of "Before rule" change in January 2004.

Uninterrupted Sleep

Crum et al. and Morrow and Crum focused on uninterrupted sleep, finding 65 percent of drivers, on average, get more than five hours of uninterrupted sleep (see Table 102).

Table 102. Amount of Uninterrupted Sleep Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Uninterrupted Sleep			
				≤ 5 Hours		> 5 Hours	
				N	%	N	%
Crum et al.[119]	2002	502	Long distance	NR	35.3	NR	64.7
Morrow & Crum[45]	2004	116	All types	42	36.2	74	63.8
Total (Mean)		**618**	**--**	**219**	**(35.4)**	**399**	**(64.6)**

NR – Not reported
* Study did not provide number of participants who responded to attribute, only the percentage of participants. For the purpose of drawing an overall mean of all studies, a number was configured based off the percentage and total number of participants.

Difficulty Sleeping

Fine et al. and Solomon et al. evaluated sleep difficulty among truck drivers, finding that 29 percent of them had a difficult time sleeping, as shown in Table 103.

Table 103. Sleep Difficulty Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Sleep Difficulty	
				N	%
Fine et al.[122]	2012	50	Long distance	17	34
Solomon et al.[141]	2008	525	Long distance	152	29
Total (Mean)		**575**	**--**	**169**	**(29.4)**

Motorcoach/bus Drivers

Howarth and Sando et al. met the inclusion criteria for this section, evaluating mean sleep time; however, Howarth assessed mean sleep time for bus driver shift workers, whereas Sando et al. evaluated all types of shift drivers. Among the findings:

- Sando et al. found the overall mean sleep time to be 6.12 hours, with a standard deviation of 1 hour, 20 minutes.
- Howarth found that split-shift workers had a mean sleep time of 7 hours and 17 minutes (437.5 minutes), with a standard deviation of 59.82 minutes. Straight-shift workers had a mean sleep time of 7 hours and 33 minutes (453.31 minutes), with a standard deviation of 59.17 minutes.

These findings are limited due to a paucity of data.

Truck and Motorcoach/bus Driver Comparison on Quality of Rest/Sleep

Data retrieved from the eight included studies reveal:

- Bus drivers, on average, get between 6 and 7.5 hours of sleep each day compared to 62 percent of truck drivers receiving 8 or more hours and 38 percent receiving less than 8 hours.
- 65 percent of truck drivers get more than 5 hours of uninterrupted sleep each day. No comparison was available for motorcoach/bus drivers.
- 29 percent of truck drivers have a difficult time sleeping. No comparison was available for motorcoach/bus drivers.

The data for these findings are limited due to a paucity of data and small sample sizes.

Opportunity for Exercise

One included study (Turner and Reed, 2011[143]) met the inclusion criteria for assessment of truck drivers' opportunity for exercise.

Truck Drivers

Turner and Reed, which observed exercise environment in a typical work week, found that exercise is minimal amongst drivers. Nearly 75 percent of participants rated the exercise environment in a typical work week as "never available/terrible."

Overall, perceived barriers to exercising were:

- Lack of time: 66.7 percent
- Lack of exercise facilities: 45.3 percent
- Concern for safety: 7.3 percent
- Health limitations: 6.3 percent
- Cost: 4.3 percent

Motorcoach/bus Drivers

No studies met the inclusion criteria for motorcoach/bus drivers.

Truck and Motorcoach/bus Driver Comparison on Opportunity for Exercise

Data retrieved from the one included study revealed:

- Nearly 75 percent of truck drivers perceive their environment to be poor or bad for exercising.
- The two biggest perceived barriers cited for not exercising were: lack of time and lack of exercise facilities.

The results of this study could be misleading as there is a paucity of data. No motorcoach/bus driver studies met the inclusion criteria for opportunities to exercise.

Section Summary for Key Question 3C

Control Over Trips

Data retrieved from one included study provided data for a group of 502 long-haul truck drivers. No comparable data were available for motorcoach/bus drivers, with the exception of the number of stops per day (one indicator of control over trips). Moreover, the number of coach drivers for this study (122 drivers) was relatively small. As a result, we are unable to make a comparison between truck and motorcoach/bus drivers with respective to control over trips.

Interactions with Passengers

Our comparison of truck and motorcoach/bus driver interactions with passengers is not directly comparable. For truck drivers, our assessment related to the drivers who drive with a co-driver or as part of a team. As the data from multiple studies reflect, the majority of long-haul drivers generally do not drive with a co-driver (65 to 91 percent of truck drivers in six independent samples of drivers, with a mean of 86 percent). We were unable to identify quantitative data regarding bus driver interactions with passengers. One included study described qualitative aspects of motorcoach/bus driver interactions with passengers, which encompassed responding to passengers' questions, addressing specific needs (eg, luggage), taking tickets, and a host of other tasks while transporting passengers from one location to another.

While there was no specific data available for this comparison, coach driver interactions with passengers is clearly an attribute that is largely different between truck and motorcoach/bus drivers.

Cabin Ergonomics

Data retrieved from the one included truck driver study revealed the following of up to 27 new long-haul freight trucks from four different manufacturers:

- Noise levels during the on-road driving were well below OSHA's permissible exposure level– 90 decibels – and/or the NIOSH's recommended value – 85 decibels for an 8-hour workday.
- Overall, vibration from all seats was generally below the ISO and European Union's exposure action level. Exposure limits were exceeded in a few trucks, but for the most part, these were isolated and probably due to the poor condition of the roadway pavement.
- For the on-road tests, in-cab concentrations of air pollutants were much lower than the concentrations measured during the parked-idling tests. Trucks have a tendency to self-pollute the cab during extended periods of parked-idling conditions because the vehicle's own exhaust enters the cab.

Scheduling/Shift Cycles

Data from six included studies revealed:

- Bus drivers (62 percent) appear to have more consistent scheduling than truck drivers (46 percent).
- The majority of bus drivers work (56 percent) straight shifts, and less than half (44 percent) work split shifts. Data to assess coach drivers on this attribute was not available.
- On a scale of 1 (to a very little extent) to 7 (to a very large extent), motorcoach drivers reported having inverted schedule to some extent, with a mean response of 4.34.

A paucity of data makes it difficult to ascertain the accuracy of these findings.

Access to Health Care

The findings of four studies assessing truck drivers' access to health care showed:

- Approximately 62 percent of truck drivers have a regular care provider.
- More than 1 in 4 truck drivers do not have health insurance.
- About 38 percent of truck drivers get insurance through their employers, while 12 percent have insurance through their spouse and 17 percent provide their own.

The results of these studies could be misleading as there is a paucity of data and the sample sizes are small. No motorcoach/bus driver studies met the inclusion criteria for access to health care.

Employment/Industry Culture

Data from three included studies revealed:

- **Morrow and Crum:** On a scale from 1 to 7 (7 meaning a lot of pressure), truck drivers feel pressured to continue driving when tired by a mean of 2.38 on the scale.
- **Reed and Cronin:** 57 percent of drivers feel pressured, at least several times a month, to complete their loads more quickly.
- **Crum et al.**: Both truck and coach drivers feel pressure to bend driving rules because of dispatchers. On a scale of 1 to 7 (7 meaning a lot of pressure), both driver groups scored in the 3 range, with truck drivers reporting a mean of 3.98 and coach drivers a 3.13. A significant difference was found between truck and coach drivers on personal motivations to continue driving when tired. Truck drivers reported a mean score of 6.59 on the 1 to 7 scale, meaning to a very large extent, whereas coach drivers reported a mean score of 2.63, meaning to a lesser extent.

The results of these studies could be misleading as there is a paucity of data and the sample sizes are small.

Exposure to Harmful Substances

Data from four included studies revealed:

- 50 percent of truck drivers are exposed to high continine (second-hand smoke) levels, 45 percent to low levels, and 5 percent to levels that are below the limit of quantitation.
- The interquartile range median (IQR) of vapor phase nicotine for nonsmokers was 0.87 (0 to 56.9). For smokers, it was 4.61 (1.44 to 51.2).
- The mean elemental carbon (in µ/gm3) was:
  - Arithmetic mean: 1.46, SD = 0.79
  - Geometric mean: 1.20, SD = 3.30
- The mean organic carbon (in µ/gm3) was:
  - Arithmetic mean: 1.46, SD = 0.79
  - Geometric mean: 1.20, SD = 3.30
- The mean PM2.5 (in µ/gm3) was:
  - Arithmetic mean: 52.6, SD = 327.7
  - Geometric mean: 23.1, SD = 2.5

The results of these studies could be misleading as there is a paucity of data. No studies met the inclusion criteria for motorcoach/bus drivers' exposure to harmful substances.

Quality of Rest/Sleep

Data from the eight included studies revealed:

- Bus drivers, on average, get between 6 and 7.5 hours of sleep each day compared to 62 percent of truck drivers receiving 8 or more hours and 38 percent receiving less than 8 hours.
- 65 percent of truck drivers get more than 5 hours of uninterrupted sleep each day. No comparison was available for motorcoach/bus drivers.
- 29 percent of truck drivers have a difficult time sleeping. No comparison was available for motorcoach/bus drivers.

The data for these findings are limited due to a paucity of data and small sample sizes.

Opportunity to Exercise

Data from the one included study revealed:

- Nearly 75 percent of truck drivers perceive their environment to be poor or bad for exercising.
- The two biggest perceived barriers cited for not exercising were: lack of time and lack of exercise facilities.

The results of this study could be misleading as there is a paucity of data. No motorcoach/bus driver studies met the inclusion criteria for opportunity to exercise.

Key Question 3D: Health-Related Behaviors/Disease Characteristics

In this section, we assess the health-related behaviors and characteristics of smoking, body mass index (BMI), physical activity, stimulant use, and alcohol use. We also look at assessments of general health, as well as diagnoses and self-reported incidence of HIV/AIDS, cancer, cardiovascular conditions, respiratory conditions, sleep disorders, renal diseases, endocrine disorders, neurological conditions, musculoskeletal disorders, mental health, and vision and hearing.

Identification of Evidence Base

The evidence base identification pathway for Key Question 3D is summarized in Figure 13. Our searches identified a total of 2,544 articles that appeared to be relevant to this key question. Following application of the retrieval criteria for this question (Appendix B: Retrieval Criteria), 75 full-length articles were retrieved and read in full. Table 104 identifies 28 of 75 retrieved articles that were found to meet the inclusion criteria (Appendix C: Inclusion Criteria) for this key question. Table D-1 of Appendix D lists the 47 articles that were retrieved, read in full, and then excluded. The table also provides justification for their exclusion.

Figure 13. Development of Evidence Base for Key Question 3D

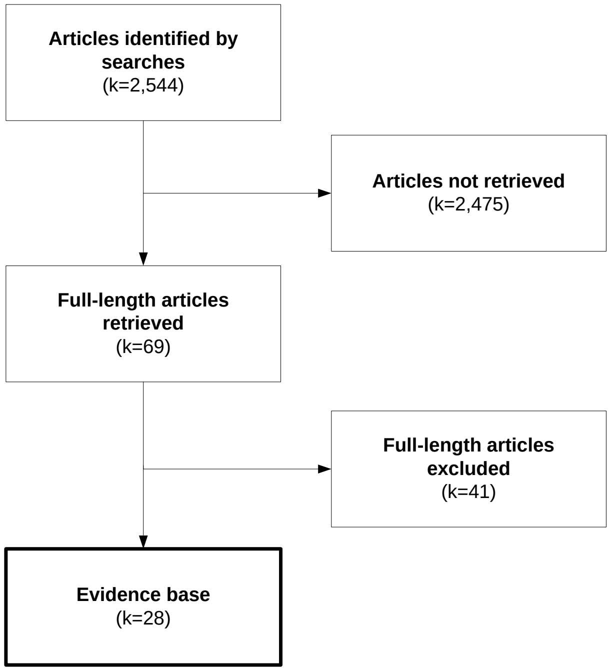


Table 104 reveals which studies are utilized in each subsection for the following categories.

Table 104. Methods for Assessing Health Characteristics for Key Question 3D

Reference	Year	Health and Disease Characteristics Reported																	
		Smoking Status	BMI	Physical Activity	Stimulant Use	Alcohol Use	General Health	HIV.AIDS	Cancer	Cardiovascular	Cerebrovascular	Respiratory	Sleep Disorders	Renal/CKD	Endocrine	Neurological	Musculoskeletal	Mental Health/Suicide	Vision or Hearing
Commercial Motor Vehicle Drivers - Truck																			
Anderson & Riley[112]	2008					✓												✓	
Chiu et al.[116]	2010	✓																	
Colt et al.[117]	2004								✓										
Couper et al.[118]	2002	✓			✓	✓													
Crum et al.[119]	2002												✓						
Davis et al.[120]	2007	✓																	
Dinges & Maislin[80]	2006	✓	✓	✓	✓	✓							✓						
Fine et al.[122]	2012		✓		✓	✓			✓	✓				✓	✓			✓	
Garshick et al.[125]	2008								✓										
Garshick et al.[124]	2002	✓																	
Jain et al.[127]	2006	✓																	
Kashima[128]	2003	✓	✓							✓									
Laden et al.[129]	2007								✓	✓									

Reference	Year	Health and Disease Characteristics Reported																	
		Smoking Status	BMI	Physical Activity	Stimulant Use	Alcohol Use	General Health	HIV.AIDS	Cancer	Cardiovascular	Cerebrovascular	Respiratory	Sleep Disorders	Renal/CKD	Endocrine	Neurological	Musculoskeletal	Mental Health/Suicide	Vision or Hearing
Layne et al.[130]	2009	✓		✓	✓		✓										✓		
Martin et al.[131]	2009		✓							✓					✓				
Pack et al.[133]	2002											✓							
Reed & Cronin[134]	2003						✓			✓		✓			✓	✓	✓	✓	✓
Robinson & Burnett[135]	2005								✓	✓									
Smith & Phillips[140]	2011		✓							✓		✓							
Solomon et al.[141]	2004						✓	✓		✓		✓	✓		✓	✓	✓	✓	✓
Stasko & Neale[142]	2007	✓			✓	✓	✓			✓		✓		✓	✓	✓	✓	✓	✓
Turner & Reed[143]	2011		✓	✓															
Watkins et al.[144]	2009											✓							
Whitfield Jacobson et al.[145]	2007		✓	✓															
Wiegand et al.[146]	2009		✓																
Xie et al.[147]	2011		✓																
Zhang et al.[148]	2005								✓										
Commercial Motor Vehicle Drivers - Motorcoach/bus																			
Escoto & French[121]	2012		✓																
Total		**9**	**10**	**4**	**5**	**5**	**4**	**1**	**6**	**9**	**0**	**6**	**1**	**2**	**5**	**3**	**4**	**5**	**3**

Evidence Base Description

This subsection provides a brief description of the key attributes of the 28 studies that compose the evidence base for Key Question 3D. Here, we discuss applicable information relevant to the quality of the included studies and the generalizability of each study's findings to truck and motorcoach/bus drivers.

Characteristics of Included Studies

The primary characteristics of the 28 included studies that address Key Question 3D are presented in Table 28. Two primary study designs (cross-sectional and cohort) characterize the studies included in the evidence base for this key question. Although the included studies assess numerous variables, that their commonality is they provide data on one or more of the 18 categories that distinguish health-related trends among truck and coach drivers.

Additional information about the studies, including location and scale of the studies (Table 27), risk of bias assessment (Table 29), and quality assessment (Table 30), can be found in the introduction of Key Question 3.

Findings

Twenty-eight studies met our inclusion criteria for Key Question 3D, which assesses the following health and disease characteristics of truck and motorcoach/bus drivers:

- Smoking status
- Body mass index (BMI)
- Physical activity level
- Stimulant use
- Alcohol use
- General health (self-described)
- HIV/AIDS status
- Cancer status
- Cardiovascular health
- Cerebrovascular health
- Respiratory health
- Presence of sleep disorders
- Renal health/chronic kidney disease
- Endocrine health
- Presence of neurological conditions
- Presence of musculoskeletal conditions
- Mental health
- Vision or hearing status

Of the 28 studies, 27 focused on truck drivers and one on bus drivers. The single study that meets inclusion criteria on bus drivers, Escoto and French (2012)[121], offers information on only BMI.

Smoking Status

Nine truck driver studies and no motorcoach/bus studies met inclusion criteria for assessing smoking status.

Truck Drivers

Nine included studies (Chiu et al., 2010[116]; Couper et al., 2002[118]; Davis et al., 2007[120]; Dinges and Maislin, 2006[80]; Garshick et al., 2002[124]; Jain et al., 2006[127]; Kashima, 2003[128]; Layne et al., 2009[130]; and Stasko and Neale, 2007[142]) met inclusion criteria and provided data on smoking status. The percent of truck drivers who self-reported they were current smokers ranged from 15 percent to 50 percent among a total of 3,977 driver participants, as shown in Table 105. The mean percent of smokers was 24.8.

Of the studies, Couper et al. did not offer data comparable to the other studies; however, it found nicotine in the urine samples of 56 percent of drivers (463 individuals) who voluntarily provided specimens for analysis during roadside inspections. This percent is significantly higher than the number of drivers who self-reported smoking in most of the studies, but it may partially be explained by exposure to secondhand smoke among drivers.

Finally, in addition to providing smoking data, Dinges and Maislin noted that 8.8 percent of the truck drivers (188 individuals) it studied reported they chewed tobacco.

Table 105. Studies' Findings for Prevalence of Smoking in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Smoking Findings			
				Current Smokers		Non-smokers	
				N =	%	N =	%
Chiu et al.[116]	2010	113	Long distance	20	17.7	93	82.3
Davis et al.[120]	2007	251	Long distance	78	31.1	173	68.9
Dinges & Maislin[80]	2006	2,187	All types	617	28.2	1570	71.8
Garshick et al.[124]	2002	107	Long distance	16	15	91	85
Jain et al.[127]	2006	1,130	Long distance	203	18	927	82
Kashima[128]	2003	109	All types	17	16	92	84
Layne et al.[130]	2009	50	Long distance	25	50	25	50
Stasko & Neale[142]	2007	30	Long distance	10	33.3	20	66.7
Total (Mean)		**3,977**	**--**	**986**	**(24.8)**	**2,991**	**(75.2)**

NR – Not reported

Motorcoach/bus Drivers

No motorcoach/bus studies met the inclusion criteria for the prevalence of smoking or tobacco use.

Truck and Motorcoach/bus Driver Comparison on Smoking Status

Data retrieved from nine included studies reveal (see Table 105):

- The percent of truck drivers who say they smoke ranges from 15 percent to 50 percent.
- 25 percent of truck drivers are smokers.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies met the inclusion criteria for motorcoach/bus drivers' smoking status.

Body Mass Index

Nine truck driver studies and one motorcoach/bus driver study met the inclusion criteria for determining prevalence of BMI.

Truck Drivers

There were nine studies (Dinges and Maislin, 2006[80]; Fine et al., 2012[122]; Kashima, 2003[128]; Martin et al., 2009[131]; Smith and Phillips, 2011[140]; Turner and Reed, 2011[143]; Whitfield Jacobsen et al., 2007[145]; Wiegand et al., 2009[146]; and Xie et al., 2011[147]) for this section; however, some studies provided only the mean BMI among drivers or did not offer comprehensive data.

Eight of the studies provided mean BMI of truck drivers, with means ranging from 30 kg/m^2 to 34.5 kg/m^2, obese (BMI $\geq$ 30 kg/m^2) category, as shown in Table 106. Five studies, with a total of 4,515 participants, provided data on three categories of BMI – normal, overweight, and obese, finding:

- The percent of obese drivers ranged from 44 to 73 percent.
- The percent of overweight (BMI = 25-29 kg/m^2) ranged from 20.3 to 39.9 percent.
- The percent of normal weight drivers ranged from 6.7 percent (this number may include some underweight drivers as well) to 19 percent.

Table 106. Body Mass Index in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Body Mass Index Findings: Normal (BMI = 18.5-24.9 kg/m²)		Overweight (BMI = 25-29 kg/m²)		Obese (BMI ≥ 30 kg/m²)		Mean BMI
				N =	%	N =	%	N =	%	
Dinges & Maislin[80]	2006	2,128	All types	216	10.3	860	39.9	1,052	49.4	32.0 (SD±0.18)
Fine et al.[122]	2012	50	Long distance	NR	NR	NR	NR	NR	NR	32.8 (SD±6.2)
Kashima[128]	2003	106	All types	20	19	39	37	47	44	30
Martin et al.[131]	2009	2,950	All types	NR	NR	NR	NR	NR	NR	32 (SD±7.3)
Smith & Phillips[140]	2011	595	NR	NR	NR	NR	NR	414‡	69.6‡	33.94
Turner & Reed[143]	2011	300	Long distance	20†	6.7†	61	20.3	219	73	34.5 (SD±7.1)
Whitfield Jacobson et al.[145]	2007	91	Long distance	12	13.2	27	29.7	52	57.1	32.63 (SD±8.02)
Wiegand et al.[146]	2009	103	NR	NR	NR	NR	NR	55‡	53.4‡	NR
Xie et al.[147]	2011	1,890	NR	326†	17.3†	679	35.9	885	46.8	30.5 (SD±6.6)
Total (Mean)		**8,213/ 4,515ᵝ**	**--**	**594**	**(13.16ᵝ)**	**1,666**	**(36.90ᵝ)**	**2,724/ 2,255ᵝ**	**(49.94ᵝ)**	**(32.30ᵝ)**

NR – Not reported; SD – Standard deviation
† May also include some underweight individuals
β Adjusted for missing data
‡ Not included in calculation of means for consistency with other studies

Motorcoach/bus Drivers

One bus driver study (Escoto and French, 2012[121]) met the inclusion criteria, providing limited data on BMI, as shown in Table 107. The study's subjects were bus operators at four transit garages in an unidentified Midwestern city. Specifics on the type of driving (ie, local, regional, or long-distance) were not given. The bus drivers' mean BMI was 32.7 kg/m^2, which is in the obese category (BMI ≥ 30 kg/m^2), and 58 percent of the 796 drivers were obese. Data on the number of overweight and normal weight drivers was not provided in the report.

Table 107. Body Mass Index in Motorcoach/bus Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Body Mass Index Findings						
				Normal (BMI = 18.5-24.9 kg/m^2)		Overweight (BMI = 30-39 kg/m^2)		Obese (BMI ≥ 30 kg/m^2)		Mean BMI in kg/m^2
				N =	%	N =	%	N =	%	
Escoto & French[121]	2012	796	Local	NR	NR	NR	NR	462	58	32.7

NR – Not reported

Truck and Motorcoach/bus Driver Comparison on Body Mass Index

Data retrieved from the 10 included studies indicate (see Table 108):

- The majority of truck and bus drivers are overweight or obese.
- The mean BMI appears to be similar for bus drivers (32.7 kg/m^2 in a single study) and truck drivers (32.30 in kg/m^2 across eight studies).

These findings are derived from limited data.

Table 108. Body Mass Index Among Truck and Bus Drivers

Population	No. of Studies	Total No. of Participants	BMI Range %			Mean BMI in kg/m^2
			Normal BMI	Overweight	Obese	
Truck drivers	8	4,515β	6.7 to 19	20.3 to 39.9	44 to 73	32.30β
Coach drivers	1	796	NR	NR	58	32.7

NR – Not reported
β Adjusted for missing data

Physical Activity Level

Four truck driver studies and no motorcoach/bus studies met the inclusion criteria for physical activity level.

Truck Drivers

Four studies (Dinges and Maislin, 2006[80]; Layne et al., 2009[130]; Turner and Reed, 2011[143]; and Whitfield Jacobson et al., 2007[145]) addressed the frequency of physical activity among truck drivers.

Three studies reported the number of days per week that truck drivers said they exercised. Among these three studies, the percent of drivers who reported exercising less than one day a week ranged between 35.9 percent and 59.2 percent among a total population of 441 drivers, as shown below on Table 109. The percent of truck drivers who reported exercising one to two days a week ranged from 22 percent to 31.5 percent. And the percent of truck drivers who reported exercising three or more days a week ranged from 14.3 percent to 32.6 percent.

It should be noted, however, that Turner and Reed and Whitfield Jacobson et al. measured only physical activity lasting 30 minutes or more, while Layne did not specify a length of time of activity.

Dinges and Maislin did not offer comparable data, but reported whether drivers said they stopped work to exercise. Of the 2,232 drivers surveyed, 24.7 percent (568 drivers), said they stopped to exercise.

Table 109. Studies' Physical Activity/Exercise in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Days of Exercise Per Week					
				0 Days/ Week		1-2 Days/Week		≥3 Days/Week	
				N =	%	N =	%	N =	%
Layne et al.[130]	2009	49	Long distance	29	59.2	13	26.5	7	14.3
Turner & Reed[143]	2011	300	Long distance	146	48.7	66	22	87	29
Whitfield Jacobson et al.[145]	2007	92	Long distance	33	35.9	29	31.5	30	32.6
Total (Mean)		**441**	**--**	**208**	**(47.17)**	**108**	**(24.49)**	**124**	**(28.12)**

Motorcoach/bus Drivers

No studies that met the inclusion criteria addressed the prevalence of exercise by motorcoach/bus drivers.

Truck and Motorcoach/bus Driver Comparison on Physical Activity Level

Data retrieved from three of the four included studies reveal (see Table 109):

- Between 35.9 percent and 59.2 percent of truck drivers say they exercise less than one day a week;
- Between 22 percent and 31.5 percent of truck drivers say they exercise one to two days a week; and
- Between 14.3 percent and 32.6 percent of truck drivers say they exercise three or more days a week.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies on motorcoach/bus drivers' physical activity met the inclusion criteria.

Stimulant Use

Five truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for prevalence of stimulant use.

Truck Drivers

Five included studies (Couper et al., 2002[118]; Dinges and Maislin, 2006[80]; Fine et al., 2012[122]; Layne et al., 2009[130]; and Stasko and Neale, 2007[142]) assessed caffeine consumption among truck drivers, but no two studies measured consumption in the same way.

Three studies surveyed truck drivers on the amount of caffeine they consumed in a day. Dinges and Maislin and Layne et al. measured the number of "caffeinated beverages" consumed, while Stasko and Neale analyzed the consumption of coffee, which has a higher caffeine content than many other caffeinated drinks. None of the studies described a standard per-serving caffeine content, however. Furthermore, Layne stated only that more than 90 percent of drivers consumed one to five caffeinated beverages daily, whereas Dinges and Maislin gave a more extensive breakdown.

Fine et al. did not report the amount of caffeine consumed, but only the mean number of days per week that truck drivers said they consumed caffeine: 5.8 days. Couper et al. reported that 94 percent of participating drivers' urine specimens (from 771 individuals who participated in voluntary screenings during roadside inspections) contained caffeine.

Couper et al. also reported that 3 percent of participating drivers' urine samples (from 25 people) contained central nervous stimulants other than caffeine or nicotine. Among these, 1.7 percent (14) contained methamphetamine or amphetamine, and 1.1 percent (9) contained cocaine or benzoylecgonine. Table 110 shows the findings of the five included studies for caffeine consumption.

Table 110. Caffeine Consumption Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Caffeinate Consumption
Couper et al.[118]	2002	820	Long distance	94% or 771 drivers consume caffeine
Dinges & Maislin[80]	2006	2,226	All types	Daily consumption <2 drinks: 550 (24.7%), SE=0.9 2-4 drinks: 1,194 (53.6%), SE=1.1 5-7 drinks: 379 (17%), SE=0.8 ≥8 drinks: 103 (4.6), SE=0.5
Fine et al.[122]	2012	50	Long distance	Daily consumption Mean of 5.8 days (SD±2.2)
Layne et al.[130]	2009	49	Long distance	Daily consumption >90% consume 1-5 caffeinated beverages daily
Stasko & Neale[142]	2007	30	Long distance	Daily consumption No coffee: 26.7% (8) ≤5 cups/day: 46.7% (14) >5 cups/day: 26.7% (8) Maximum reported: 20 cups/day

SE – Standard error; SD – Standard deviation

Motorcoach/bus drivers

No studies met the inclusion criteria for stimulant use among motorcoach/bus drivers.

Truck and Motorcoach/bus Driver Comparison on Stimulant Use

Data retrieved from five included studies reveal:

- The majority of truck drivers consume between 1 and 5 cups of caffeine a day
- 17 to 26.7 percent of truck drivers consume more than 5 cups a day.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies on motorcoach/bus drivers' smoking status met the inclusion criteria.

Alcohol Use

Five truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for prevalence of alcohol use.

Truck Drivers

Five studies (Anderson and Riley, 2008[112]; Couper et al., 2002[118]; Dinges and Maislin, 2006[80]; Fine et al., 2012[122]; and Stasko and Neale, 2007[142]) addressed the prevalence of alcohol use among truck drivers; however only Anderson and Riley, Dinges and Maislin, and Stasko and Neale provide comparable data. Among these three studies, the mean percent of truck drivers who reported they drank alcohol was 43 percent, with a range from 33.6 to 63 percent, among 3,231 participants, as shown in Table 111.

Table 111. Alcohol Use Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Alcohol Use Findings			
				Drinkers		Non-drinkers	
				N =	%	N =	%
Anderson & Riley[112]	2008	987	Long distance	622	63	365	37
Dinges & Maislin[80]	2006	2,214	All types	745	33.6	1,469	66.4
Stasko & Neale[142]	2007	30	Long distance	13	43.3	17	56.7
Total (Mean)		**3,231**	**--**	**1,380**	**(42.71)**	**1,851**	**(57.29)**

Two additional studies reported the following:

- Fine et al. reported that the mean number of days per week that drivers drank alcohol was 0.5, with a standard deviation of ±1.0.
- Anderson and Riley reported how frequently drivers reportedly drank alcohol, although this study provided a more extensive breakdown than did Fine et al. (see Table 112).

Table 112. Frequency of Alcohol Use Among Truck Drivers who Drink

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Frequency of Drinking Among Drivers who Drink									
				<1 time/ month		1-2 times/ month		Several times/month		1-2 days/ week		Almost daily	
				N =	%	N =	%	N =	%	N =	%	N =	%
Anderson & Riley[112]	2008	986	Long distance	383	38.79	363	36.82	110	11.13	111	11.29	19	1.96

Couper et al. reported that 1.3 percent of drivers (11 individuals) who voluntarily provided urine specimens for analysis during roadside inspections tested positive for alcohol.

Motorcoach/bus Drivers

No studies that met the inclusion criteria addressed the prevalence of alcohol use by motorcoach/bus drivers.

Truck and Motorcoach/bus Driver Comparison on Alcohol Use

Data retrieved from five included studies reveal (see Table 111 and Table 112):

- 43 percent of truck drivers, on average, drink alcohol, with prevalence ranging between 33.6 and 63 percent.
- 39 percent of truck drivers drink alcohol less than once a month.
- 11 percent of truck drivers drink alcohol once or twice a week.

Due to a paucity of data and small sample sizes, the results of this section are limited. No studies on motorcoach/bus drivers' alcohol use met the inclusion criteria.

General Health Assessment

Four truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for general health assessment of drivers.

Truck Drivers

Four included studies (Layne et al., 2009[130]; Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) addressed drivers' assessment of their own health. However, each study employed a survey with a slightly different scale or reported only partial survey results, making them inappropriate for comparison.

Solomon et al. and Stasko and Neale found that on average (see Table 113):

- 9.3 percent of truck drivers consider their health to be excellent.
- 83 percent of truck drivers consider themselves to be in good, very good or excellent health.
- 16 percent of truck drivers consider their health to be fair.

- 27 percent of truck drivers consider their health to be fair, poor or terrible.
- Less than 1 percent of drivers consider their health to be poor.

Table 113. How Truck Drivers Assess Their Own Health

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Health Assessment											
				Excellent		Very Good		Good		Fair		Poor		Terrible	
				N =	%	N =	%	N =	%	N =	%	N =	%	N =	%
Solomon et al.[141]	2004	512	Long distance	46	9	152	29.2	229	45	82	16	3	0.6	NR	NR
Stasko & Neale[142]	2007	30	Long distance	5	16.7	NR	NR	16	53.3	7	23.3	1	3.3	1	3.3
Total (Mean)		**551**	**--**	**51**	**(9.3)**	**152**	**(29.2β)**	**245**	**(44.5)**	**89**	**(16.2)**	**4**	**(0.7)**	**1**	**(3.3β)**

NR – Not reported
β Adjusted for missing data.

Layne et al., which assessed difference between men and women, reported less than 20 percent of drivers of either gender rated their own health as excellent or very good, but most rated their health as good or fair. Reed and Cronin, 2003, which assessed only women drivers, reported that most rated their health to be excellent, very good, or good, while 6.3 percent (18) of the total 284 drivers rated their health as fair or poor.

Motorcoach/bus Drivers

No studies that met the inclusion criteria addressed motorcoach/bus drivers' assessment of their own health.

Truck and Motorcoach/bus Driver Comparison on General Health Assessment

Data retrieved from the five included studies reveal (see Table 113):

- Most truck drivers (83 percent) consider themselves to be in good, very good or excellent health.

- 27 percent of truck drivers consider their health to be fair, poor or terrible

Due to a paucity of data and small sample sizes, the results of this section are limited. No studies on motorcoach/bus drivers' assessment of their health met the inclusion criteria.

HIV/AIDS

One truck driver study and no motorcoach/bus driver studies met the inclusion criteria for assessment of HIV/AIDS prevalence.

Truck Drivers

One study (Solomon et al., 2004[141]) addressed the prevalence of HIV/AIDS in truck drivers, finding that two drivers (0.4 percent of the study population) self-reported on an anonymous, self-administered health survey that a health professional had diagnosed them with HIV/AIDS.

Motorcoach/bus Drivers

No motorcoach/bus studies met the inclusion criteria addressing the prevalence of HIV/AIDS.

Truck and Motorcoach/bus Driver Comparison on HIV/AIDS

One included study reveals:

- Infection of HIV/AIDS is rare among truck drivers (0.4 percent).

Due to a paucity of data and small sample size, the result of this section is limited. No studies on motorcoach/bus drivers assessing prevalence of HIV/AIDS met the inclusion criteria.

Cancer

Six truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for assessing cancer risk.

Truck Drivers

Six included studies (Colt et al., 2004[117]; Fine et al., 2012[122]; Garshick et al., 2008[125]; Laden et al., 2007[129]; Robinson and Burnett, 2005[135]; and Zhang et al., 2005[148]) addressed various aspects of cancer risk in truck drivers; however, none of the data offered were comparable.

Colt et al. concluded there was an increased risk of bladder cancer (OR=2.4, 95% CI=1.4-4.1) among male truck drivers, and risk significantly rose with increasing duration of employment (see Table 114). Meanwhile, Zhang et al. reported an increased risk of pancreatic cancer among truck drivers, including those employed in the industry for less than 10 years (adjusted OR=3.1, 95% CI= 1.1-8.8), as well as those working in the industry for 10 years or longer (adjusted OR=1.1, 95% CI=0.5-2.6).

Fine et al. noted that 2 percent of drivers (one of 50 participants) reported having a history of cancer other than skin cancer.

Three studies assessed lung cancer mortality in truck drivers; however, all record the data in different ways. Garshick et al. assessed the lung cancer mortality percent change per year of work and hazard ratios (HRs) associated with cumulative years of work as a long-haul driver. The percent change per year of work is 2.5 (95% CI, 0.2-4.9). The multivariate HR for 20 years of work is 1.65 (95% CI, 1.04-2.62). Laden et al., 2007, calculated the standardized mortality ratio (SMR) for lung cancer among long-haul drivers (SMR = 1.10; 95% CI, 1.02–1.19). Finally, Robinson and Burnett evaluated the proportionate mortality ratio (PMR) for lung cancer for numerous subsets of long-haul drivers from 1979 to 1990 by age, gender, and race. For example, for white males, ages 15-54, PMR=1.21; 95% CI, 1.16-1.27.

Table 114. Cancer Prevalence Among Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Cancer Risk
Colt et al.[117]	2004	424 truck cases; 645 controls employed in various industries	Long distance	Bladder cancer risk (OR=2.4, CI=1.4-4.1) Significant positive trend in risk with increasing duration of employment (Ptrend = 0.0003)
Fine et al.[122]	2012	50	Long distance	History of cancer N (%) 1 (2)
Garshick et al.[125]	2008	31,135	Long distance	Lung cancer risk Person years: 161,503 Lung cancer deaths: 323 Percent change per year of work: OR=2.5 (95% CI, 0.2-4.9) Smoking adjustment factor: 1.17 HR for 20 years of work: Multivariate OR=1.65 (95% CI, 1.04-2.62) Smoking adjusted: OR=1.40 (95% CI, 0.88-2.24)
Laden et al.[129]	2007	36,299	All types	Lung cancer Mortality rates among drivers: SMR = 1.10; 95% CI, 1.02–1.19
Robinson & Burnett[135]	2005	74,315	Long distance	Lung cancer White males, age 15-54 (n=1,312): PMR=1.21 (95% CI, 1.16-1.27) White males, age 15-64 (n=4,302): PMR =1.18 (95% CI, 1.15-1.21) White males, age ≥ 65 (n=4,253): PMR=1.17 (95% CI, 1.14-1.20) Black males, age 15-54 (n=267): PMR=1.17 (95% CI, 1.04-1.37) Black males, age 15-64 (n=708): PMR=1.08 (95% CI, 1.01-1.17)
Zhang et al.[148]	2005	376 cases; 2,434 controls	Long distance	Pancreatic cancer Heavy-truck drivers: Case/control: 11/58 Adjusted OR=1.5 (95% CI, 0.8-3.0) Crude OR=1.3 (95% CI, 0.7-2.6) Heavy-truck drivers employed <10 years in industry: Case/control: 5/13 Adjusted OR=3.1 (95% CI, 1.1-8.8) Crude OR=3.3 (95% CI, 1.1-9.9) Heavy-truck drivers employed ≥10 years in industry: Case/control: 6/45 Adjusted OR=1.1 (95% CI, 0.5-2.6) Crude OR=0.9 (95% CI, 0.3-2.1)

CI – Confidence interval; HR – Hazard ratio; OR – Odds ratio; PMR – Proportionate mortality ratio; SMR – Standardized mortality ratio

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for cancer prevalence.

Truck and Motorcoach/bus Driver Comparison on Cancer

The six included studies reveal:

- Truck drivers face an increased risk for developing:
  - Bladder cancer (OR=2.4, 95% CI=1.4-4.1), with risk increasing every year of driving.
  - Pancreatic cancer in the first 10 years of driving (adjusted OR=3.1, 95% CI= 1.1-8.8).
  - Lung cancer (multivariate HR for 20 years of work=1.65, 95% CI, 1.04-2.62)

Due to a paucity of data, the results of this section are limited. No motorcoach/bus studies assessing cancer prevalence met the inclusion criteria.

Cardiovascular Conditions

Nine truck driver studies and no motorcoach/bus studies met inclusion criteria for assessing cardiovascular conditions.

Truck Drivers

Nine studies (Fine et al., 2012[122]; Kashima, 2003[128]; Laden et al., 2009[129]; Martin et al., 2009[131]; Reed and Cronin, 2003[134]; Robinson and Burnett, 2005[135]; Smith and Phillips, 2011[140]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) evaluated the prevalence of various cardiovascular conditions in truck drivers.

Seven studies provided prevalence rates for hypertension, two calculated prevalence rates for heart problems. One study noted drivers' self-reported history of heart attacks and heart rhythm problems. Two studies reported ischemic heart disease mortality rates among truck drivers, although the data are not reported in a way that is comparable, and one study reported mortality rates for acute myocardial infarction.

Seven studies assessed hypertension prevalence in truck drivers (self-reported and records), finding the drivers with hypertension ranged from 15.5 to 41 percent among 4,539 drivers. The mean percent of drivers with hypertension was 36.8 percent, as shown in Table 115.

In Solomon et al. and Stasko and Neale, drivers were asked whether they had been diagnosed by a health professional as having heart or cardiovascular problems. The percent of drivers who reported such problems ranged from 6 to 10 percent among a total of 551 driver participants, also seen in Table 115.

Table 115. Prevalence of Cardiovascular Conditions in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Cardiovascular Conditions			
				Hypertension		Heart/Cardiovascular Problems	
				N =	%	N =	%
Fine et al.[122]	2012	50	Long distance	8	16	NR	NR
Kashima[128]	2003	109	All types	43	40	NR	NR
Martin et al.[131]	2009	2,950	All types	1,210	41	NR	NR
Reed & Cronin[134]	2003	284	Long distance	44	15.5	NR	NR
Smith & Phillips[140]	2011	595	NR	235	39.5	NR	NR
Solomon et al.[141]	2004	521	Long distance	119	23	34	6
Stasko & Neale[142]	2007	30	Long distance	11	36.7	3	10
Total (Mean)		**4,539**	**--**	**1,670**	**(36.8)**	**--**	**--**
		551				**37**	**(6.72)**

A history of heart rhythm problems was self-reported by 2 percent of drivers (one of 50 participants) in Fine et al., as was a history of heart attack.

Laden et al. reported the SMR for ischemic heart disease in truck drivers (SMR=1.49; 95% CI, 1.40–1.59), and Robinson & Burnett calculated the PMR for ischemic heart disease for numerous subsets of long-haul drivers from 1979-1990 by age, gender, and race. White males, ages 15 to 54 had a PMR of 1.09 (95% CI, 106-112).

Robinson and Burnett also reported the PMR for acute myocardial infarction among subsets of drivers from 1979-1990. White males, ages 15-54, had a PMR of 1.12 (95% CI, 1.08-1.16).

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for assessing cardiovascular conditions.

Truck and Motorcoach/bus Driver Comparison on Cardiovascular Conditions

Data retrieved from nine included studies reveal (seeTable 115):

- Between 15.5 and 41 percent of truck drivers have hypertension.
- The mean percent of drivers with hypertension is 36.8.
- Between 6 and 10 percent of truck drivers have been diagnosed as having heart or cardiovascular problems.

Due to a paucity of data, the results of this section are limited. No motorcoach/bus driver studies met the inclusion criteria for assessing cardiovascular conditions.

Cerebrovascular Conditions

No truck driver or motorcoach/bus driver studies met the inclusion criteria for the prevalence of cerebrovascular conditions.

Respiratory Conditions

Six truck driver studies (Pack et al., 2002[133]; Smith and Phillips, 2011[140]; Watkins et al., 2009[144]; Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) and no motorcoach/bus driver studies met the inclusion criteria for evaluating the prevalence of respiratory conditions.

Truck Drivers

Sleep Apnea

Pack et al. focused on sleep apnea, finding that among its 1,391 participants:

- 17.6 percent (245) had mild sleep apnea.
- 5.8 percent (81) had moderate sleep apnea.
- 4.7 percent (65) had severe sleep apnea.

Smith and Phillips and Watkins et al. used screening tools to determine whether groups of drivers might have obstructive sleep apnea. In Smith and Phillips, 55.9 percent (333 drivers) of a total 595 truck drivers had positive scores on the Berlin Sleep Questionnaire. Meanwhile, Watkins et al. found that 32 percent (109 drivers) of 340 drivers screened positive for a high probability of OSA at an occupational medical clinic.

Sinus Problems

Three included studies assessed the prevalence of sinus problems in truck drivers, finding 17 to 50 percent of drivers had been diagnosed with sinus problems by a health professional, as shown in Table 116. The mean percent of drivers with sinus problems was 21.91.

Table 116. Prevalence of Sinus Problems in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Drivers with Sinus Problems	
				N =	%
Reed & Cronin[134]	2003	284	Long distance	79	27.8
Solomon et al.[141]	2004	512	Long distance	87	17
Stasko & Neale[142]	2007	30	Long distance	15	50
Total (Mean)		826	--	181	(21.91)

Reed and Cronin and Solomon et al. assessed asthma and chronic bronchitis in truck drivers, finding (see Table 117):

- 5 to 5.3 percent had been diagnosed with asthma by a health professional.

- 2 to 4.2 percent had been diagnosed with chronic bronchitis by a health professional.

Table 117. Studies' Findings for Prevalence of Asthma and Chronic Bronchitis in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Drivers with Asthma		Drivers with Chronic Bronchitis	
				N =	%	N =	%
Reed & Cronin[134]	2003	284	Long distance	15	5.3	12	4.2
Solomon et al.[141]	2004	521	Long distance	26	5	11	2
Total (Mean)		805	--	41	(5.09)	23	(2.86)

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for assessing respiratory conditions.

Truck and Motorcoach/bus Driver Comparison on Respiratory Conditions

Data retrieved from six included studies revealed (see Table 116 and Table 117):

- The mean percent of truck drivers with sleep apnea:
  - 17.6 percent of truck drivers have mild sleep apnea.
  - 5.8 percent of truck drivers have moderate sleep apnea.
  - 4.7 percent of truck drivers had severe sleep apnea.
- The mean percent of truck drivers with sinus problems is 22 percent, with ranges from 17 to 50 percent.
- The mean percent of truck drivers with asthma is 5 percent, with ranges from 5 to 5.3 percent.
- The mean percent of truck drivers with chronic bronchitis is 3 percent, with ranges from 2 to 4.2 percent.

No motorcoach/bus driver studies met the inclusion criteria for assessing respiratory conditions.

Sleep Disorders

Three truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for assessing sleep disorders.

Truck Drivers

Three included studies (Crum et al., 2002[119]; Dinges and Maislin, 2006[80]; and Solomon et al., 2004[141]) reported on sleep disorders, in general, finding a mean percent of 6 percent of drivers having been diagnosed with a sleep disorder. The range of drivers who reported being diagnosed with a sleep disorder was 2.6 to 12 percent among a total of 2,042 driver participants, as shown in Table 118.

Table 118. Prevalence of Sleep Disorders in Truck Drivers

Study	Year	Number	Types of Driving	Drivers with Sleep Disorders

		of Drivers	(Long distance, Local or Regional)	N =	%
Crum et al.[119]	2002	279	Long distance	NR	2.6
Dinges & Maislin[80]	2006	2,242	All types	126	5.6
Solomon et al.[141]	2004	521	Long distance	62	12
Total (Mean)		**3,042**	**--**	**195**	**(6.41)**

NR – Not reported
* Study did not provide number of participants who responded to attribute, only the percentage of participants. For the purpose of drawing an overall mean of all studies, a number was configured based off the percentage and total number of participants.

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria addressing the prevalence of sleep disorders.

Truck and Motorcoach/bus Driver Comparison on Sleep Disorders

Data retrieved from three included studies revealed (see Table 118):

- The mean percent of truck drivers with sleep disorders is 6.41 percent, with ranges from 2.6 to 12 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria for assessing sleep disorders.

Renal Disorders

Two truck driver studies and no motorcoach/bus studies met the inclusion criteria for assessment of renal disorder prevalence.

Truck Drivers

Two studies (Fine et al., 2012[122]; and Stasko and Neale, 2007[142]) found that a mean of 10 percent of truck drivers had kidney problems, with a range from percent 6 to 16.7 percent, as shown in Table 119.

Table 119. Prevalence of Renal Disorders in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Drivers with Kidney Problems	
				N =	%
Fine et al.[122]	2012	50	Long distance	3	6
Stasko & Neale[142]	2007	30	Long distance	5	16.7
Total (Mean)		**80**	**--**	**8**	**(10.0)**

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for prevalence of renal disorders.

Truck and Motorcoach/bus Driver Comparison on Renal Disorders

Data retrieved from two included studies revealed (see Table 119):

- A mean of 10 percent of truck drivers have had kidney problems, with a range from 6 to 16.7 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria for prevalence of renal disorders.

Endocrine disorders

Five truck driver studies and no motorcoach/bus studies met the inclusion criteria for assessing the prevalence of endocrine disorders.

Truck Drivers

Five included studies (Fine et al., 2012[122]; Martin et al., 2009[131]; Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) evaluated diabetes prevalence, finding that 14.17 percent of truck drivers, on average, had the disease. Among the studies, the percent of drivers with diabetes ranged from 6 to 16 percent, as shown in Table 120.

Table 120. Prevalence of Diabetes in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Drivers with Diabetes	
				N =	%
Fine et al.[122]	2012	50	Long distance	3	6
Martin et al.[131]	2009	2,950	All types	472	16
Reed & Cronin[134]	2003	284	Long distance	12	4.2
Solomon et al.[141]	2004	490*	Long distance	49	10
Stasko & Neale[142]	2007	30	Long distance	3	10
Total (Mean)		**3,804**	**--**	**539**	**(14.17)**

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria assessing endocrine disorder prevalence.

Truck and Motorcoach/bus Driver Comparison on Renal Disorders

Data retrieved from five included studies revealed (see Table 120):

- The mean percent of drivers with diabetes is 14 percent, with a range of 6 to 16 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing endocrine disorder prevalence.

Neurological Disorders

Three truck driver and no motorcoach/bus studies met the inclusion criteria to evaluate the prevalence of neurological conditions.

Truck Drivers

Three included studies (Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) assessed the prevalence of neurological conditions in truck drivers, specifically migraines. The percent of drivers who suffered migraines ranged from 8 to 30 percent among a total driver population of 804. The mean percent of drivers who reported having migraines was 12.06 percent, as shown on Table 121.

Table 121. Prevalence of Migraines in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Migraines	
				N =	%
Reed & Cronin[134]	2003	284	Long distance	49	17.3
Solomon et al.[141]	2004	490	Long distance	39	8
Stasko & Neale[142]	2007	30	Long distance	9	30
Total (Mean)		**804**	**--**	**97**	**(12.06)**

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for assessing the prevalence of neurological conditions.

Truck and Motorcoach/bus Driver Comparison on Renal Disorders

Data retrieved from three included studies reveal (see Table 121):

- The mean percent of drivers who have migraines is 12 percent.
- The range of truck drivers who have suffered migraines is between 8 and 30 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing the prevalence of neurological conditions.

Musculoskeletal Disorders

Four truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for assessing musculoskeletal disorder prevalence.

Truck Drivers

One or more of the four included studies (Layne et al., 2009[130]; Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) assessed the prevalence of back pain, back problems, arthritis, and neck pain.

Reed and Cronin and Solomon et al. found that 37 percent of drivers, on average, suffer back pain, with a range of 18.3 to 47 percent having back pain among a total 803 driver participants, as shown in Table 122. It should be noted that Reed and Cronin surveyed the number of truck drivers who said they had been diagnosed by a health professional with back pain, and Solomon inquired whether drivers had suffered back pain (diagnosed or not), specifically within the previous month.

Table 122. Prevalence of Back Pain in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Back Pain	
				N =	%
Reed & Cronin[134]	2003	284	Long distance	52	18.3
Solomon et al.[141]	2004	519	Long distance	244	47
Total (Mean)		**803**	**--**	**296**	**(36.86)**

Solomon et al. and Stasko and Neale found that 28 percent of drivers suffer from back problems, on average, with a range of 26 to 60 percent having back problems among a total of 503 driver participants, as shown in Table 123. However, Solomon et al. asked drivers whether they had been diagnosed with back problems, while Stasko and Neale asked whether drivers had back problems. The wide range of percentages reported may be a reflection of the difference in wording on the questionnaires used.

Table 123. Prevalence of Back Problems in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Back Problems	
				N =	%
Solomon et al.[141]	2004	507	Long distance	132	26
Stasko & Neale[142]	2007	30	Long distance	18	60
Total (Mean)		**537**	**--**	**150**	**(27.93)**

Reed and Cronin reported that 11.3 percent of drivers had been diagnosed by a health professional as having arthritis, while Stasko and Neale reported that 46.7 percent of drivers suffered from painful joints or arthritis. Among drivers surveyed by Solomon et al., 33 percent had suffered neck pain within the previous month.

Layne et al. reported that 32 percent of men (eight people) and 32 percent of women (eight people) surveyed had work-related musculoskeletal injuries as a long-haul driver.

Motorcoach/bus Drivers

No motorcoach/bus driver studies met the inclusion criteria for evaluating prevalence of musculoskeletal conditions.

Truck and Motorcoach/bus Driver Comparison on Musculoskeletal Disorders

Data retrieved from four included studies revealed (see Table 123):

- 37 percent of truck drivers, on average, suffer back pain, with a range of 18.3 to 47 percent.

- 28 percent of drivers suffer from back problems, on average, with a range of 26 to 60 percent.
- 11.3 to 47 percent of drivers suffer from painful joints or arthritis.
- 32 percent of men and 32 percent of women have had work-related musculoskeletal injuries as a long-haul driver.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing the prevalence of musculoskeletal disorders.

Mental Health Conditions

Five truck driver studies and no motorcoach/bus driver studies met the inclusion criteria for evaluating prevalence of mental health conditions.

Truck Drivers

One or more of the five included studies (Anderson and Riley, 2008[112]; Fine et al., 2012[122]; Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) assessed depression, "emotional or psychiatric problems," stress, and issues related to potential substance abuse.

Three studies assessed depression in truck drivers, finding nearly 10 percent of truck drivers suffer from depression – either self-reported or diagnosed by a health professional. The range of truck drivers suffering from depression was 8.5 to 26.7 percent among a total 836 driver participants, as shown in Table 124. The self-reported figure was significantly higher than the percentages for the two studies that asked about diagnoses of depression, however. Solomon et al., in addition to reporting on diagnosed depression as noted in the table, also found that 14 percent of drivers said they had felt depressed within the previous month.

Table 124. Prevalence of Depression in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Depression	
				N =	%
Reed & Cronin[134]	2003	284	Long distance	24	8.5
Solomon et al.[141]	2004	522	Long distance	47	9
Stasko & Neale[142]	2007	30	Long distance	8	26.7
Total (Mean)		**836**	**--**	**79**	**(9.45)**

Fine et al. reported that 6 percent of drivers (3 of 50 participants) suffered emotional or psychiatric problems. Stasko and Neale reported on stress, using a tool called the Modified Trucker Strain Monitor (TSM). The authors stated that 10 percent of drivers (three people) had a Modified TSM score greater than or equal to 4. They also noted that 53.3 percent of drivers (16) reported feeling excessive stress at work.

Anderson and Riley asked truck drivers several questions related to potential substance abuse, finding that 14.12 percent (139 drivers) of truck drivers had tried without success to cut down on or quit drugs and/or alcohol, while 2.87 percent (28 people) said they take a drink to make things more manageable. In Solomon et al., 2 percent (10 drivers) reported having been diagnosed with drug or alcohol dependency by a health professional. And Stasko and Neale found that 6.7 percent of drivers (two people) had a CAGE score above 2 – suggesting potential alcohol dependency.

Motorcoach/bus Drivers

No motorcoach/bus studies met the inclusion criteria for assessing the prevalence of mental health conditions.

Truck and Motorcoach/bus Driver Comparison on Mental Health Conditions

Data retrieved from four included studies revealed (see Table 124):

- Nearly 10 percent of truck drivers suffer from depression – either self-reported or diagnosed by a health professional.
- 53.3 percent of drivers feel excessive stress at work.
- 2 percent reported having been diagnosed with drug or alcohol dependency by a health professional.
- 14.12 percent of truck drivers have tried without success to cut down on or quit drugs and/or alcohol.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing the prevalence of mental health disorders.

Vision and Hearing

Three truck driver studies and no motorcoach/bus studies met the inclusion criteria for assessing the prevalence of conditions related to vision. No truck or motorcoach/bus studies met the inclusion criteria for assessing the prevalence of conditions related to hearing.

Truck Drivers

Three included studies (Reed and Cronin, 2003[134]; Solomon et al., 2004[141]; and Stasko and Neale, 2007[142]) found that 18 percent of truck drivers, on average, had been diagnosed with vision problems by a health professional. The range of truck drivers with vision problems was 12 to 70 percent among 831 drivers that provided data on this variable, as shown in Table 125.

Table 125. Studies' Findings for Prevalence of Vision Problems in Truck Drivers

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Vision Problems	
				N =	%
Reed & Cronin[134]	2003	284	Long distance	34	12

Study	Year	Number of Drivers	Types of Driving (Long distance, Local or Regional)	Findings on Vision Problems	
				N =	%
Solomon et al.[141]	2004	517	Long distance	93	18
Stasko & Neale[142]	2007	30	Long distance	21	70
Total (Mean)		**831**	**--**	**148**	**(17.81)**

Motorcoach/bus Drivers

No studies met the inclusion criteria for evaluating the prevalence of vision or hearing problems in motorcoach/bus drivers.

Truck and Motorcoach/bus Driver Comparison on Vision and Hearing Problems

Data retrieved from three included studies revealed (see Table 125):

- Nearly 18 percent of truck drivers have vision problems, with a range of 12 and 70 percent among the studies.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies met the inclusion criteria for evaluating the prevalence of vision or hearing problems in motorcoach/bus drivers.

Section Summary for Key Question 3D

Smoking Status

Data retrieved from nine included studies revealed:

- The percent of truck drivers who say they smoke ranges from 15 percent to 50 percent.
- 25 percent of truck drivers are smokers.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies met the inclusion criteria for motorcoach/bus drivers' smoking status.

Body Mass Index

Data retrieved from the 10 included studies indicated:

- The majority of truck and bus drivers are overweight or obese.
- The mean BMI appears to be similar for bus drivers (32.7 kg/m^2 in a single study) and truck drivers (32.30 in kg/m^2 across eight studies).

The paucity of data makes it difficult to ascertain the accuracy of these findings.

Physical Activity Level

Data retrieved from three of the four included studies revealed:

- Between 35.9 percent and 59.2 percent of truck drivers say they exercise less than one day a week;
- Between 22 percent and 31.5 percent of truck drivers say they exercise one to two days a week; and
- Between 14.3 percent and 32.6 percent of truck drivers say they exercise three or more days a week.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies on motorcoach/bus drivers' physical activity met the inclusion criteria.

Stimulant Use
Data retrieved from the five included studies revealed:

- The majority of truck drivers consume between 1 and 5 cups of caffeine a day.
- 17 to 26.7 percent of truck drivers consume more than 5 cups a day.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No studies on motorcoach/bus drivers' stimulant use met the inclusion criteria.

Alcohol Use
Data retrieved from five included studies revealed:

- 43 percent of truck drivers, on average, drink alcohol, with prevalence ranging between 33.6 and 63 percent.
- 39 percent of truck drivers drink alcohol less than once a month.
- 11 percent of truck drivers drink alcohol once or twice a week.

Due to a paucity of data and small sample sizes, the results of this section are limited. No studies on motorcoach/bus drivers' alcohol use met the inclusion criteria.

General Health Assessment
Data retrieved from the four included studies revealed:

- Most truck drivers (83 percent) consider themselves to be in good, very good or excellent health.
- 27 percent of truck drivers consider their health to be fair, poor or terrible

Due to a paucity of data and small sample sizes, the results of this section are limited. No studies on motorcoach/bus drivers' assessment of their health met the inclusion criteria.

HIV/AIDS
One included study revealed:

- Infection of HIV/AIDS is rare among truck drivers (0.4 percent).

Due to a paucity of data and small sample size, the result of this section is limited. No studies on motorcoach/bus drivers' prevalence of HIV/AIDS met the inclusion criteria.

Cancer

Six included studies revealed:

- Truck drivers face an increased risk for developing:
    - Bladder cancer (OR=2.4, 95% CI=1.4-4.1), with risk increasing every year of driving.
    - Pancreatic cancer in the first 10 years of driving (adjusted OR=3.1, 95% CI= 1.1-8.8).
    - Lung cancer (multivariate HR for 20 years of work=1.65, 95% CI, 1.04-2.62)

Due to a paucity of data, the results of this section are limited. No motorcoach/bus studies assessing cancer prevalence met the inclusion criteria.

Cardiovascular Conditions

Data retrieved from nine included studies revealed:

- Between 15.5 and 41 percent of truck drivers have hypertension.
- The mean percent of drivers with hypertension is 36.8.
- Between 6 and 10 percent of truck drivers have been diagnosed as having heart or cardiovascular problems.

No motorcoach/bus driver studies met the inclusion criteria for assessing cardiovascular conditions.

Cerebrovascular Conditions

No truck driver or motorcoach/bus driver studies met the inclusion criteria for the prevalence of cerebrovascular conditions.

Respiratory Conditions

Data retrieved from six included studies revealed:

- The mean percent of truck drivers with sleep apnea:
    - 17.6 percent of truck drivers have mild sleep apnea.
    - 5.8 percent of truck drivers have moderate sleep apnea.
    - 4.7 percent of truck drivers had severe sleep apnea.
- The mean percent of drivers with sinus problems is 22 percent, with ranges from 17 to 50 percent.
- The mean percent of drivers with asthma is 5 percent, with ranges from 5 to 5.3 percent.
- The mean percent of drivers with chronic bronchitis is 3 percent, with ranges from 2 to 4.2 percent.

No motorcoach/bus driver studies met the inclusion criteria for assessing respiratory conditions.

Sleep Disorders

Data retrieved from three included studies revealed:

- The mean percent of truck drivers with sleep disorders is 6.41 percent, with ranges from 2.6 to 12 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria for assessing sleep disorders.

Renal Disorders

Data retrieved from two included studies revealed:

- A mean of 10 percent of truck drivers have had kidney problems, with a range from 6 to 16.7 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria for prevalence of renal disorders.

Endocrine Disorders

Data retrieved from five included studies revealed:

- The mean percent of drivers with diabetes is 14 percent, with a range of 6 to 16 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing endocrine disorder prevalence.

Neurological Disorders

Data retrieved from three included studies revealed:

- The mean percent of drivers who have migraines is 12 percent.
- The range of truck drivers who have suffered migraines is between 8 and 30 percent.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing the prevalence of neurological disorders.

Musculoskeletal Disorders

Data retrieved from four included studies revealed:

- 37 percent of truck drivers, on average, suffer back pain, with a range of 18.3 to 47 percent.
- 28 percent of drivers suffer from back problems, on average, with a range of 26 to 60 percent.

- 11.3 to 47 percent of drivers suffer from painful joints or arthritis.
- 32 percent of men and 32 percent of women have had work-related musculoskeletal injuries as a long-haul driver.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing the prevalence of musculoskeletal disorders.

Mental Health Conditions

Data retrieved from four included studies revealed:

- Nearly 10 percent of truck drivers suffer from depression – either self-reported or diagnosed by a health professional.
- 53.3 percent of drivers feel excessive stress at work.
- 2 percent reported having been diagnosed with drug or alcohol dependency by a health professional.
- 14.12 percent of truck drivers have tried without success to cut down on or quit drugs and/or alcohol.

The paucity of data makes it difficult to ascertain the accuracy of these findings. No motorcoach/bus driver studies met the inclusion criteria assessing the prevalence of mental health disorders.

Vision and Hearing

Data retrieved from three included studies revealed:

- Between 12 percent and 70 percent of truck drivers had vision problems; and
- The average percent of drivers who reported vision problems was about 18 percent.

No studies on the prevalence of vision and hearing problems in motorcoach/bus drivers met the inclusion criteria.

Section Summary for Key Question 3A-D

This report found a few similarities and differences between truck and coach drivers; however, far more data was available for truck drivers than motorcoach/bus drivers. Of the 39 included studies that met the inclusion criteria for this section, only three provided data for bus drivers and one for coach drivers. Hence, the paucity of data for motorcoach/bus drivers, and in some cases truck drivers, makes the accuracy of our findings difficult to ascertain and unreliable.

Similarities between truck and motorcoach/bus drivers reveal:

- The majority are men.
- The majority are white.

- Approximately 50 percent of drivers have high school diplomas.
- The majority earn less than $55,000 a year.
- About 50 percent of drivers are married.
- They average about 7 hours of sleep each day.
- The majority are overweight or obese, with a mean BMI of 32.

Differences between truck and motorcoach/bus drivers revealed:

- More women drive motorcoach/bus (22.2 percent) than truck (4.5 percent).
- More black individuals appear to drive motorcoach/bus (27 percent) than truck (14 percent), but this data is based on BLS data, which includes other drivers that are not the focus of this report.
- Motorcoach/bus drivers are about four years older than truck drivers, on average, with a mean age of about 48 and 44, respectively.
- BLS data shows that more motorcoach/bus drivers are 45 years and older compared to truck drivers, 73 percent vs. 52 percent. This is likely due to the increasing number of motorcoach/bus drivers in the 65-year and older age group, which grew from 7.4 percent in 2002 to 16 percent in 2011.
- BLS data shows that more truck drivers (18 percent) have less than a high school diploma compared to motorcoach/bus drivers (11 percent). Furthermore, more motorcoach/bus drivers, on average, have some college or received an associate degree or higher (39 percent) than truck drivers (29 percent).
- Truck drivers have consistently earned more than motorcoach/bus drivers (excluding school bus and special client bus drivers); however, over the past 10 years, motorcoach/bus drivers' income has grown faster than truck drivers.
- Motorcoach/bus drivers have, on average, about six more years of job experience than truck drivers (10.6 years vs. 16.6 years, respectively).
- Bus drivers spend most of their time driving in the city, whereas truck drivers spend most of their time on the interstate. Data for coach drivers could not be found.
- Motorcoach/bus drivers, on average, drive half as many miles as truck drivers per week: 1,200 miles vs. 2,449 miles.
- Long-distance truck drivers, on average, drive about two hours more a day than straight and split-shift bus drivers: 10 hours vs. 8 hours.
- More motorcoach/bus drivers (62 percent) have consistent daily schedules as opposed to truck drivers (50 percent).

Key Question 4: Do identified differences between motorcoach and truck drivers increase (or decrease) the risks for acute non-pathologic fatigue?

This key question sought to determine whether identified differences between coach and truck drivers could lead to increases/decreases in fatigue among coach drivers compared with truck drivers. Differences in demographics, job function, work environment, and health might render the coach driver more or less susceptible to acute fatigue.

No studies that examined the differences between coach and truck drivers and their fatigue risk were found. Therefore, to address Key Question 4, it was first necessary to independently identify the significant risk factors for acute fatigue. Next, our task was to connect these fatigue risk factors with the demographic, job function, work environment, and health characteristics of coach and truck drivers examined in Key Question 3. Finally, we set about comparing the predominance of these fatigue risk factors among truck drivers as compared with their predominance in coach drivers.

Because identification of fatigue risk factors was not among the primary goals of this report, and because there was an abundance of studies relating to fatigue, we limited our search to relevant FMCSA reports and literature reviews. Furthermore, although the prevalence of certain risk factors is apt to vary among different countries as drivers of trucks and motorcoaches are influenced by culture and legislation, the risk factors themselves do not observe international boundaries and are also unlikely to change significantly over time. For this reason, our search for literature reviews on risk factors for acute fatigue was broadened to include foreign reviews as well as reviews published as long ago as 1990.

Literature reviews that focused specifically on vehicle crash risk linked to fatigue were not the target of our searches; however, in some incidences, reviews on crash risk also included information on risk factors for fatigue. These reviews were included in our analysis when appropriate to flush out the available evidence on fatigue risk factors.

This search uncovered literature reviews examining the relationship between fatigue and several demographic, job, and health characteristics considered in Key Question 3. A summary of the characteristics identified and their assessment in the literature follows.

Demographic Risk Factors

The literature considered several demographic traits as potential influences on fatigue level. Addressed in at least one review each were:

- Age
- Gender
- Race/ethnicity
- Socioeconomic status
- Education
- Marital status.

Age

Several reviews (Di Milia et al., 2011[35]; Nicholson, 1999[37]; Muecke, 2004[36]) find advancing age to be a risk factor for acute fatigue in the context of a particular job characteristic

– shift work, which is discussed more extensively below, under risk factors tied to job function and work environment. According to Di Milia, a wide-ranging narrative review of demographic factors and fatigue: "Aging is associated with a more difficult adjustment of circadian rhythms to changes in the sleep/wake cycle, increased sleep disturbances, and reduced tolerance for working extended (≥12-h) shifts. These difficulties reflect the effort and circadian adjustment required in making the transition from day to night work, which may become less bearable with advancing age."

Circadian rhythm is a sort of 24-hour biological clock that tells us when to sleep. Muecke explains that as part of this process, the hormone cortisol is released primarily in the morning and helps with daytime waking. Conversely, the hormone melatonin causes drowsiness and is secreted by the pineal gland only when the environment is dark.

Muecke, a narrative review focusing on nurses, concurs with Di Milia: "The ability of the circadian cycle to adjust constantly to the changing sleep patterns that must be endured by the rotational night nurse is diminished with age." Muecke cites one study suggesting that around age 40 or 50, even permanent night workers may struggle with nocturnal schedules.

Irregular schedules and night work may be particularly difficult for older workers, according to Di Milia, Nicholson, and Muecke, in part, because the circadian rhythm adjusts so that older persons are more inclined to "morningness" – they become sleepy and prefer to go to sleep earlier at night and awaken earlier in the morning, thus making it difficult to stay alert for night shifts. Di Milia also states, without citation, that "the critical age of shiftwork intolerance seems to be (about) 45-50 years."

Other reviews cite studies with contrasting findings related to age and acute fatigue. In a systematic review of 53 studies on factors related to fatigue, Tiesinga et al., 1999[38], finds older ages to be associated with lower fatigue scores. It should be noted, however, that the studies reviewed in Tiesinga involved populations selected for particular health characteristics; for example, several studies focus on cancer patients; others on chronic fatigue sufferers, pregnant women, heart patients, etc. Tiesinga's assessment of age as a risk factor examines four studies: one focused on patients of a general practitioner, a second looked at cancer patients, a third assessed patients with chronic fatigue syndrome, and a fourth evaluated post-partum women.

Duke et al., 2010[43], is a narrative review devoted specifically to questions of age and professional heavy vehicle driver safety. Duke notes a lack of consistency in studies attempting to connect CMV driver sleepiness with age. In some of these studies, being a younger driver of a heavy commercial vehicle is associated with a higher risk of sleepiness at work. In other studies, Duke cites that older drivers are more at risk for fatigue-related crashes, and in some, there is no statistically significant association with age.

Gender

Three reviews were found that address the relationship between gender and fatigue. Two of these conclude that women are at increased risk for fatigue compared to men, and one considers the question unresolved.

While noting potential confounding factors such as different types of work performed, distinct domestic burdens, and inconsistent job training, Di Milia states the literature "suggests females better recognize or are at greater risk of fatigue than males, especially when involved in night shiftwork."

Tiesinga also concludes that female gender has a positive correlation with fatigue. Here, Tiesinga's assessment is based on a review of six studies, two of them involving general practice patients, and the others considering patients with cancer, rheumatoid arthritis, chronic heart failure, and chronic fatigue syndrome. All six studies find a positive correlation between female gender and fatigue.

Meanwhile, Nicholson, a narrative review that focuses on shift work and health, concludes that studies on the relationship between gender and fatigue "show inconsistent results or no effect."

Race and Ethnicity

The one review identified that addresses race/ethnicity as a potential risk factor for fatigue notes the dearth of research on the topic. Di Milia points to one study in which middle- and upper-income blacks reported greater than 1.5 times the level of fatigue reported by whites in the same income bracket. However, Di Milia points out the results of international studies suggesting that job characteristics, such as shift schedule, type of work, and job control may account for many differences in fatigue among workers of different races and ethnicities.

Di Milia also identifies one study that found sleep duration to be linked with race, with black men and women averaging less sleep than whites. Di Milia's authors suggest that sleep deprivation may therefore help explain any higher proclivity toward fatigue among blacks.

Socioeconomic Status

Di Milia and Tiesinga were the only reviews found that evaluated the role of socioeconomic status (SES) as a risk factor for fatigue. Tiesinga cites only one study on patients with chronic fatigue syndrome, which found a correlation between upper- and middle-class individuals and higher levels of fatigue.

Di Milia, meanwhile, suggests that studies on the role of socioeconomic status in acute fatigue too often fail to separately consider the SES variables of education, occupation, and income, as well as how they interact with other demographic characteristics such as blue-collar/white-collar job, working arrangement, and overtime. We will consider the variables of education and working hours in separate sections below.

Education Level

Di Milia and Tiesinga were also the only reviews found that evaluated the role of education level as a risk factor for fatigue.

Tiesinga reviewed three studies that considered a link between education level and fatigue. Two of the studies, whose subjects were post-partum women and patients with chronic heart failure, respectively, found a higher level of education to be negatively correlated with fatigue. However, a third study involving patients of a general practitioner found the opposite, an increased likelihood of fatigue among patients with a higher level of education.

Di Milia also discusses the mixed results of studies on education level and fatigue. In one study cited, less educated participants report greater fatigue on composite measures of general fatigue, physical fatigue, reduced activity, and reduced motivation, but not mental fatigue. Two other studies are consistent with this assessment, Di Milia states. Nonetheless, as in the case of socioeconomic factors in general, Di Milia considers the literature that attempts to correlate education level with fatigue risk to have too many confounding factors related to demographics to be elucidating.

Marital Status

Di Milia, the sole review to evaluate marital status in relation to fatigue, points to one study that found that employees who lived alone had significantly higher levels of fatigue than their co-workers who did not. However, the review points out that the study was unclear whether the employees who lived alone also worked more hours. Furthermore, the Di Milia review does not indicate that the individuals who shared a home were married or partnered; that is to say, it is possible some lived with roommates.

Weighing further data on family-related fatigue, Di Milia ultimately posits that having a spouse "may lessen the domestic burden and consequent fatigue, particularly for men, but not necessarily women, as working females still carry the overall greater domestic load."

Risk Factors Tied To Job Function and Work Environment

Job function and work environment are tabled separately for the purpose of Key Question 3, in which our studies dealt exclusively with truck and motorcoach/bus drivers. However, because there is much overlap in attributes related to job function and work environment, and because the category descriptions used in studies of other populations do not always neatly align with descriptions of professional driver work, it makes sense to consider job function and work environment together for Key Question 4.

Our searches turned up literature reviews that considered several characteristics of job function and work environment as potential influences on fatigue level. Addressed in at least one review each were shift work (including day, night, and rotating schedules), long hours/overtime, heavy work/loading, delivery pressures, commute time, level of job autonomy/control, single vs. team driving, and monotony of task.

Shift Work/Schedules

The reviews included here consider the impact of rotating schedules, as well as day and night shift schedules, on fatigue risk. As in the majority of the literature, the term "shift work" will be used to refer to rotating schedules that involve some night shifts. Shift work and night work are among the risk factors for fatigue that appear most reliably in the literature reviews found. In fact, all 10 reviews that address shift work suggest that rotating schedules put workers at risk for fatigue. Two additional reviews limit their remarks to the night shift only, and both find night work to be a contributor to fatigue.

Niu et al., 2011[50], is a systematic review that looks specifically at the effects of shift work on employees. Niu concludes that rotating shift work and night work disrupt normal circadian rhythms and thus hurt sleep quality, leading to fatigue. The review explains: "When night shift workers sleep during the day, their sleep cycles are reduced, and sleep quality is poor because of high cortisol concentration and low melatonin levels."

Niu et al. suggests that employees who must work on a rotating schedule adjust more readily if the schedule rotates forward (ie, daytime schedule followed by evening schedule, followed by nighttime schedule). A 2003 narrative review by Akerstedt et al.[47] argues that there is no solid evidence the direction of rotation makes a difference for shift workers – but Niu was published eight years later and cites more recent studies on this point.

Akerstedt et al., which also focuses on night work and shift work, concurs that "irregular work hours" interfere with the circadian rhythm, reducing sleep quality and increasing fatigue. Akerstedt says that "One reason for the night shift sleepiness is that the individual is exposed to work at the nadir (low point) of the well-established circadian pattern." The review notes that the effects on sleep and alertness tend to linger even on workers' days off.

Nicholson et al., another review that covers shift workers from various industries, states simply that fatigue is an "established consequence" of shift work.

A narrative review that looks at road crash risk for drivers of both commercial vehicles and passenger vehicles, Smolensky et al., 2011[51], agrees that shift workers and night workers are likely to suffer sleep deprivation and face a greater risk of fatigue than do daytime workers.

Lal and Craig, 2001[40], points specifically to professional drivers who must drive when their circadian cycle is at its low. The narrative review also points out that irregular work schedules may "negatively influence" the periods available for sleep. And a 2007 FMCSA report on driver fatigue by Eskandarian et al.[39] comes to similar conclusions.

Apostolopoulos et al.[48], in a 2010 narrative review discussing health risks for truck drivers, takes what may be the next logical step, highlighting connections between "fragmented and erratic work schedules" and fatal crashes. And in a literature review preceding a study on truck drivers, Morrow and Crum, 2004[45], also states that irregular driving schedules have been linked to fatigue, and "driving patterns that run counter to circadian rhythms have been shown to result in falling asleep while driving and crashes."

Other relevant reviews highlight the dangers of night work specifically, rather than rotating shift work. Leibowitz et al.[49], a 2006 narrative review on excessive daytime sleepiness, states that employees who "regularly" work night shifts experience more disrupted sleep, as well as sleepiness during waking hours, than do daytime workers. Muecke discusses one study asserting that fatigue "accumulates faster" during night work compared with day work. Orris et al., 2005[154], is an FMCSA-sponsored narrative review of truck and motorcoach/bus driver health and fatigue issues. It concludes that night driving is associated with poor sleep and with "more falling-asleep incidents."

There is some discussion in the literature as to whether the bodies of workers who consistently work the night shift can adapt to this schedule such that fatigue is no longer a particular problem. Akerstedt deduces that this can occur to some extent, but probably not completely, because exposure to daylight helps keep the circadian rhythm aligned for daytime activity. Muecke cites studies suggesting that circadian adjustment may indeed occur with night shift workers, with one study positing that the process takes several days or weeks but may never truly be complete. Niu does not cite specific sources but states that it takes about seven days for a worker's circadian rhythm to completely adjust from day shifts to night shifts.

Meanwhile, a study reported by Di Milia suggests that in order to truly adapt to nighttime work hours, workers must maintain a similar schedule on their days off. However, Di Milia reports on another study with the same lead author that uses melatonin as a marker for circadian rhythm adjustment and concludes that just 25 percent of permanent night workers achieve some level of adjustment and fewer than 3 percent attain complete adjustment. Di Milia summarizes that "the relatively sparse literature on permanent night shiftwork indicates that very few employees show biological and social adjustment to this working arrangement."

When it comes to the day shift, Di Milia points out, two factors can have a significant effect on fatigue: the shift's duration (see section below on long work hours) and its commencement. One review, Akerstedt, found that rising early (between 4 a.m. and 5 a.m.) for a morning shift can leave a worker sleepy for the rest of the day, as this too interferes with a person's circadian clock. And Di Milia reports that "Commencing work too early in the morning is linked with short sleep duration and higher sleepiness."

Finally, it is important to reiterate the interplay between shift work/night work and other factors that may lead to increased fatigue. As described in the age and gender sections above, some studies have found shift work to be a particular risk factor for fatigue among older workers and women. Furthermore, long work hours, addressed below, can combine with shift work and compound the resulting sleep debt and consequent fatigue.

Long Work Hours/Overtime

Our searches uncovered several reviews (Di Milia; Eskandarian; Lal and Craig; and Morrow and Crum) that examine whether extended driving hours are a risk factor for fatigue. Additionally, we found reviews (Caruso et al., 2004[42]; Di Milia; Duke; Horne et al, 1999[44]; Lal and Craig; Nicholson; Orris et al., 2005[154]; Smith et al., 1998[155]; and Van der Hulst, 2003[46]) that considered whether long work hours in general contribute to fatigue risk. Most of the above reviews suggested that correlations were likely. Unfortunately, few offered specifics on a particular cutoff point for the number of hours that can safely be driven, or worked, before the issue of fatigue becomes critical.

Di Milia finds studies with conflicting conclusions on the impact of extended driving hours, but notes that longer working hours in general have been linked to "increased subjective complaints of fatigue." The review points to one study in which employees who worked a 65-hour week "reported a significantly greater likelihood of 'general fatigue' and 'chronic fatigue'" than did those who worked 50 to 64 hours a week.

Di Milia points out, however, that a worker's response to overtime is likely to vary based on a number of factors, including scheduling, as well as "job demands and control, voluntary versus mandatory overtime and rewarded versus non-rewarded overtime."

According to studies cited by Lal and Craig, crash data implicate fatigue in vehicle crashes that occur after "very long" driving hours. Lal and Craig states that driving or working for "a sustained period of time" can increase fatigue, and also asserts that fatigue is compounded after six consecutive days of driving. The FMCSA report by Eskandarian et al. links increased driving time with fatigue as well as crash risk.

Morrow and Crum suggests that it's difficult to pinpoint the number of hours a truck driver can drive before becoming fatigued because truckers, the review states, often drive more hours than legally permissible and tend to keep inaccurate logbooks. Nonetheless, it continues, "A large number of investigations have demonstrated that long driving hours increase fatigue and crash risk."

An FMCSA-sponsored narrative review by Orris, on the other hand, suggests that, at least according to one study, long daytime driving hours might not be a significant contributor to fatigue if drivers get enough sleep.

Duke and Nicholson each state, with little comment, that prolonged work hours increase fatigue. Meanwhile, a narrative review by Horne takes a distinct perspective in considering the potential threat of a worker spending 12 hours on the clock at a non-driving job and getting in a fatigue-related vehicle crash on the way home from work. Horne cites a study comparing the fatigue levels of employees after 12-hour and 8-hour shifts. Those who worked 12 hours were found to be "significantly more sleepy" than the others.

Smith, in a narrative review that focuses on the effects on workers of 12-hour versus 8-hour shifts, finds the evidence equivocal when it comes to longer work shifts and fatigue. It should be noted, however, that since this review does not look at the schedules of professional drivers specifically, the workers examined may conform to a "compressed" schedule that requires fewer total hours of work within any given week. That is to say, a 12-hour shift may provide the payoff of a longer sequence of days off for the workers studied, which may not be the case for truck or motorcoach/bus drivers.

Finally, two narrative reviews focused specifically on long work hours. Van der Hulst, 2003[46], looked at six studies on long work hours and five of them found a correlation between extended hours and fatigue, although this link was in some cases only valid for certain subgroups of workers. Caruso, et al., 2004[42], published by the National Institute for Occupational Safety and Health (NIOSH), recounts that four studies found that workers reported feeling especially fatigued during the ninth to 12th hours of work.

Sleep Debt

Sleep debt, put simply, is the difference between the amount of sleep a person needs and the amount a person actually gets over a given period of time. The reviews we found concur that sleep debt is a significant – if not the most significant – cause of fatigue. They also show that although sleep debt may have any number of causes, two job-related factors – shift/night work and long hours – are particular hazards for professional drivers. Health-related factors such as obstructive sleep apnea may also be important, as we will see in the health section below.

Two reviews point out shortfalls of seemingly small to moderate amounts of sleep can add up quickly to have a major impact on fatigue. Akerstedt notes that night work can interfere with sleep and, citing two studies, asserts that "a week of 4.5 hours of sleep may yield sleepiness close to levels seen in total sleep deprivation." Eskandarian sees sleep disruption as an additional contributor to sleep debt and points to another study that says losing just one or two hours of sleep a night can lead to serious sleep debt over time. Meanwhile, in a more extreme example, Muecke suggests night shift nurses may be shortchanging their sleep by up to four hours a night, meaning they can accumulate a large sleep debt in just a week.

Leibowitz points to a sleep experiment that found volunteers' daytime sleepiness to be directly proportional to the number of hours of sleep lost, and Niu cites several studies in asserting that "large" sleep deficits can lead to chronic fatigue. Leibowitz describes one poll indicating that a large number of adults sleep fewer hours on weeknights, suggesting they use weekends to "repay" sleep debt. The review notes that this can be an effective way to make up sleep.

Duke and Eskandarian each list several studies that have found sleep debt to be a factor in fatigue-related crashes, and Apostolopoulos states that "fragmented and erratic work schedules that result in sleep deprivation … have been empirically linked with fatal crashes."

Williamson et al.[41], a 2011 narrative review on fatigue and safety, acknowledges that sleep loss or poor quality sleep can lead to sleep debt, and says there is "considerable evidence from motor vehicle crash studies that sleep restriction is associated with increased risk of crash involvement." Williamson says that evidence is strongest "with respect to acute, severe sleep loss, but has also been shown with respect to chronic partial sleep restriction."

As noted in the shift work section above, Smolensky asserts that sleep deprivation is common in shift workers and night workers and they face a greater risk of fatigue than do daytime workers.

Heavy Work/Loading

Two reviews mention the potential impact of truck loading on fatigue. Without elaboration, Lal and Craig cites one study that lists "heavy cargo handling" as a factor likely to increase fatigue. Meanwhile, Morrow and Crum concludes that drivers have a strong economic incentive to help load and unload trucks because it speeds up their return to the road and to earning a living. According to the review, this has mixed effects on driver alertness and fatigue. Citing one study, Morrow and Crum says loading and unloading "initially improve alertness by providing diversion and exercise; however, these effects wear off quickly and result in decreased driving performance after 12 hours of duty."

Delivery Pressures

Morrow and Crum, in the literature review that precedes the authors' own study on this topic and several others, cites one study that says dispatchers choose whether to accept or reject loads based primarily on the revenue that would be generated. They suggest this may make dispatchers prone to accept high-revenue loads even when drivers may not be able to deliver them on time and still get adequate (and legally required) breaks for sleep.

Commute Time

Di Milia, the only review to consider commute time at any length, calls it "an important variable that can contribute to fatigue," asserting that a long commute can add considerably to the demands of a workday as well as impinge on sleep time. Di Milia concludes, however, that the literature on commute time as it relates to fatigue is very limited. Caruso, the NIOSH report, makes a similar observation about the literature on commute time as it relates to health in general.

Job Control/Autonomy

Job control is another variable that Di Milia finds potentially significant when it comes to worker fatigue. In a study of employees who worked one to eight hours of overtime a week, those who were fatigued "reported higher levels of job demand paired with less decision-latitude and less work motivation" compared with workers who did not complain of fatigue, Di Milia reports.

Caruso cites one study that reported that 12-hour shifts with some flexibility in start times were associated with improved sleep quality and alertness. This review again concludes, however, that "few studies have examined … how worker control over their work time and mandatory overtime might influence their health."

Single vs. Team Driving

Several studies were cited in a literature review by Orris et al., 2005, on health and fatigue issues associated with team vs. solo driving amongst truck and motorcoach/bus drivers. For example, an on-road study by Klauer et al, 2003[156] found that truck drivers who drove alone were involved in four times as many very drowsy/extremely drowsy incidents as team drivers, and were "more likely to push themselves when they were very tired." Another study by Feyer, et al.[157] reported that two-up drivers (i.e., team drivers) reported and showed evidence of greater fatigue than single drivers before the trip started and appeared to be more fatigued overall for most of the trip. Also of note, over the homeward leg of the trip, team drivers in this study reported no change in the level of fatigue, with fatigue having peaked at mid trip. In contrast, for solo drivers, fatigue was reported to peak at the end of the homeward leg.

Monotony of Task

Three reviews found indications that monotonous tasks increase the risk of fatigue. Lal and Craig find several studies that tie monotonous work or driving conditions to fatigue. The review also states that "Fatigue or sleepiness is frequently reported in night-time drivers and is thought to be a major factor in crashes occurring in monotonous driving conditions."

Williamson posits that work tasks that are monotonous, boring, or lack stimulation can contribute to mental and physical fatigue. Recalling the term "highway hypnosis," the review continues: "In the context of traffic safety, the monotony of driving at night and motorway driving are of particular concern, especially for long trips."

In an audit of United Kingdom crashes cited by Williamson, higher traffic density was found to be linked with an increased rate of sleep-related crashes in urban driving settings, but was protective on the highway. Williamson asserts this suggests that lack of stimulation can be a factor in fatigue-related highway crashes. Nonetheless, the review acknowledges finding no controlled studies documenting monotony as a causal factor in fatigue crashes.

Eskandarian cites several studies linking monotonous driving with fatigue and crash risk. The studies implicate particular road types, including long stretches of highway, highways at night, straight roads with little traffic, and rural roads.

Health-related Risk Factors

Our searches revealed several literature reviews that considered health-related conditions as potential risk factors for fatigue. The reviews we found tended to take a broad view of primary fatigue risk factors, and this list of health-related risk factors is not exhaustive. As an example, the role of various medications on fatigue was beyond the scope of this report.

However, addressed in at least one review each were sleep disorders, obesity, diabetes, depression or anxiety, cancer, and physical activity. A final section lists other health-related conditions the reviews mentioned as potential risk factors for fatigue that are dealt with in less detail because they are less relevant in our comparison of coach and bus drivers.

Sleep Disorders

Eskandarian lists sleep disorders among risk factors for fatigue and, citing two studies, states that "individuals with sleep apnea and other sleep disorders that cause excessive daytime sleepiness are at high risk for accidents."

Leibowitz points to several sleep disorders that can cause fragmented sleep, potentially increasing fatigue. These include sleep apneas such as obstructive sleep apnea (OSA) and movement disorders such as periodic limb movements of sleep (PLMS), although Leibowitz observes that the association of PLMS with sleep disturbance is less established. This review also covers disorders such as narcolepsy, but they are not discussed here because they would preclude an individual from driving a CMV of any type and/or are beyond the scope of this report.

According to Smolensky, sleep disorders are the most common sources of daytime fatigue and sleepiness. Patients with OSA face non-restorative and "continuously disrupted" sleep, the review on sleep disorders, medical conditions, and fatigue states. Smolensky cites two 1990s studies in estimating that the prevalence of OSA in professional drivers ranges from 26 percent to 50 percent, and lists more than 10 studies it says "reveal a clear positive relationship between OSAS and traffic accidents." The review also states that PLMS and restless legs syndrome can cause "severe daytime fatigue and somnolence."

Duke includes sleep disorders among a list of risk factors for fatigue, citing one study. The review later cites another study in which the driving histories of truck drivers found to have sleep-disordered breathing and those who were obese showed twofold higher crash rates than the histories of other drivers.

Vgontzas et al., 2006[52], is a narrative review on obesity and fatigue. This review acknowledges a role for obstructive sleep apnea in daytime sleepiness, but suggests that the severity of sleep disordered breathing (apnea-hypopnea index and nocturnal hypoxemia) is less of a predictor of fatigue than are obesity, diabetes, and age.

Obesity

Obesity is an established risk factor for OSA, as noted in Vgontzas and Leibowitz and in the 2007 FMCSA evidence report *Obstructive sleep apnea and commercial motor vehicle driver safety*[158]. The evidence report states: "OSA is more common in obese individuals. It is estimated that 70% of individuals with a BMI >25 have OSA. OSA worsens in severity and prevalence with increasing obesity."

Vgontzas, however, cites seven different studies to make an argument that, in addition to being a risk factor for OSA – which is a commonly accepted risk factor for fatigue – obesity is in its own right a risk factor for fatigue. If so, the relationship appears complex. Vgontzas states that "obese patients without sleep apnea are sleepier compared to nonobese controls whereas within the morbidly obese, those who have high sleep efficiency at night are sleepier than those who have low sleep efficiency."

The review proposes that "obesity-related objective daytime sleepiness and fatigue are associated primarily with metabolic and psychological factors and less with sleep apnea and sleep disruption per se. Furthermore … objective sleepiness is primarily related to metabolic factors, whereas fatigue appears to be related to psychological distress."

Duke too lists several studies that mention obesity as a risk factor for fatigue, but does not elaborate on the studies' findings. And Smolensky includes metabolic syndrome/obesity on a list of nearly 50 chronic medical conditions that can potentially compromise sleep and/or elevate daytime feelings of fatigue. It does not elaborate.

Diabetes

Three reviews mention diabetes as a possible risk factor for fatigue. Acknowledging that the underlying mechanism is unknown, Vgontzas states that fatigue is a frequent complaint of diabetic patients. The review asserts that studies with large random samples of the general population have found metabolic disturbances including diabetes and obesity to be among the top determinants of subjective excessive daytime sleepiness. Vgontzas cites several studies linking diabetes, impaired glucose tolerance, or insulin resistance with fatigue.

Meanwhile, Smolensky includes diabetes on its list of medical conditions that can potentially compromise sleep and/or elevate daytime feelings of fatigue. The review does not elaborate.

Depression or Anxiety

Noting that depression is on the North American Nursing Diagnosis Association's list of risk factors related to fatigue, Tiesinga also finds a correlation between depression and fatigue in all eight of the studies it examines on the topic. As stated earlier, the studies in Tiesinga each cover specific populations; in this case, patients with heart problems, Parkinson's disease, rheumatoid arthritis, multiple sclerosis or systematic lupus erythematosus, and chronically fatigued patients (two studies), as well as women in early pregnancy and on "well woman" visits.

Tiesinga summarizes: "The correlation between depression and fatigue among different (patient) populations showed that these factors are significantly related: most depressed patients are fatigued."

Along with metabolic disturbances, Vgontzas asserts that studies with large random samples of the general population have found depression to be among the primary determinants of subjective excessive daytime sleepiness. Two studies cited by Vgontzas also found anxiety to be a major predictor of excessive daytime sleepiness.

Leibowitz, citing one study, remarks that "tiredness, fatigue, and lack of energy are reported by most patients with major depression … fatigue and lack of energy appear to be more common in depressed patients than is actual sleepiness." Smolensky includes clinical depression/major depressive disorder and anxiety syndrome on its extensive list of conditions that may compromise sleep and/or elevate daytime feelings of fatigue, but it provides no further information.

Physical Activity

Seeing a link between metabolic disorders, sleep apnea, and fatigue, and noting that exercise can improve insulin resistance and reduce visceral adipose tissue, Vgontzas looks at the effect of exercise on fatigue. The review finds that "In obese, apneic men, regular exercise was associated with a significant reduction of sleepiness after controlling for weight, apnea, age, depression, cardiovascular problems, and diabetes."

Vgontzas also reviews the Third National Health and Nutrition Examination Survey (NHANES III), and says it showed that persons who engaged in "insufficient physical activity" were two times as likely to report feeling "tired" and four times as likely to report feeling "exhausted," compared to the group that reported feeling "fresh." Separately, Vgontzas reports that a study found physical inactivity to be independently related to fatigue in a large random sample of Swedish women.

Cancer

Studies have found that cancer patients have prevalence rates of 54 percent to 68 percent for "feeling drowsy" and 21 percent to 40 percent for being "overly sleepy," according to Leibowitz. The review acknowledges the existence of many potential confounding factors, such as older age, depression, effects of treatments including medication and chemotherapy, and other factors.

Smolensky includes cancer on its list of chronic medical conditions that can potentially compromise sleep and/or elevate daytime feelings of fatigue but does not elaborate.

Other Health-Related Conditions

Leibowitz also points out that excessive daytime sleepiness can be caused by head trauma and encephalitis, neurodegenerative disorders such as Parkinson's disease and Alzheimer's disease, fibromyalgia, congestive heart failure, hypothyroidism, various psychiatric disorders, medications, and other conditions.

In addition to the health conditions already covered above, Smolensky lists the following chronic conditions as potential contributors to fatigue: alcoholism, allergic and non-allergic rhinitis, anemia, anorexia, asthma/nocturnal asthma, ataxia, bipolar disorder, bulimia nervosa, cerebrovascular disease, chronic fatigue syndrome, chronic pain syndromes, COPD (bronchitis and emphysema), coronary heart disease, dementia, dyskinesia, dystonia, epilepsy, gastroesophageal reflux disorder, head trauma, heart failure, hepatic disease, Huntington's disease, hyperthyroidism, hypothyroidism, illicit drug abuse, insomnia, manic disorder, migraine, multiple sclerosis, nocturia, osteoarthritis, Parkinson's disease, peptic ulcer disease, renal failure, respiratory failure, rheumatoid arthritis, schizophrenia, and spastic torticollis.

Summary of Risk Factors for Acute Fatigue

Table 126 provides a summary of risk factors for non-pathologic or acute fatigue that were identified for each of the review articles examined in this section. They are organized by each of the domains addressed in Key Question 3: A) demographics, B) job function, C) work environment, and D) health.

Table 126. Risk Factors for Acute Fatigue by Reviews Examined

Factors Found to Increase Risk for Fatigue					
Reference	**Year**	**A) Demographics**	**B) Job function**	**C) Work environment**	**D) Health**
Akerstedt et al.[47]	2003			• Shift work • Sleep debt	
Apostolopoulos et al.[48]	2010			• Shift work • Sleep debt	
Caruso et al.[42]	2004			• Long work hours	
Di Milia et al.[35]	2011	• Older age combined with shift work • Female gender combined with shift work		• Job control	
Duke et al.[43]	2010			• Long work hours • Sleep debt	• Sleep-disordered breathing • Obesity
Eskandarian et al.[39]	2007			• Long driving hours • Sleep debt • Monotonous driving conditions	• Sleep apnea
Horne & Reyner[44]	1999			• Long work hours	
Lal & Craig[40]	2001		• Loading/ unloading	• Shift work • Long driving hours • Long work hours • Monotonous driving conditions	
Leibowitz et al.[49]	2006			• Shift work • Sleep debt	• Sleep apnea • Periodic limb movements of sleep • Depression • Cancer
Morrow & Crum[45]	2004		• Loading/unloading • Delivery pressures	• Shift work • Long driving hours	

Factors Found to Increase Risk for Fatigue					
Reference	**Year**	**A) Demographics**	**B) Job function**	**C) Work environment**	**D) Health**
Muecke[36]	2004	• Older age combined with shift work		• Shift work • Sleep debt	
Nicholson[37]	1999	• Older age combined with shift work		• Shift work • Long work hours	
Niu et al.[50]	2011			• Shift work • Sleep debt	
Orris et al.[154]	2005			• Shift work • Driving alone	
Smith et al.[155]	1998				
Smolensky et al.[51]	2011			• Shift work • Sleep debt	• Sleep apnea • Periodic limb movements of sleep • Restless legs syndrome • Obesity • Diabetes • Depression • Anxiety • Cancer
Tiesinga et al.[38]	1999	• Female gender			• Depression
Van der Hulst[46]	2003			• Long work hours	
Vgontzas et al.[52]	2006				• Sleep apnea • Obesity • Diabetes • Depression • Anxiety • Physical activity
Williamson et al.[41]	2011			• Sleep debt • Monotonous driving conditions	

Table 127 below provides a high-level summary of key risk factors for acute fatigue that are related to each of the domains addressed in Key Question 3: A) demographics, B) job function, C) work environment, and D) health-related.

Table 127. Summary of Risk Factors for Acute Fatigue by Question 3 Categories

Factors Found to Increase Risk for Fatigue			
A) Demographics	**B) Job function**	**C) Work environment**	**D) Health**
• Older age combined	• Loading/unloading	• Shift work	• Sleep-disordered

with shift work • Female gender combined with shift work • Female gender	tasks • Delivery pressures • Long driving hours • Monotonous driving conditions	• Sleep debt • Long work hours • Job control	breathing • Obesity • Sleep apnea • Periodic limb movements of sleep • Depression • Cancer • Restless legs syndrome • Diabetes • Anxiety • Cancer • Physical activity

Findings for Key Question 4

Based on the findings from Key Question 3A-D (see Table 128), and given the findings regarding risk factors for acute fatigue described above (see Table 127), the following conclusions emerge below.

Table 128. Identified Differences/Similarities Between Truck and Motorcoach/bus Drivers

Key Question 3 Findings			
A: Demographics	**B: Job Function**	**C: Work Environment**	**D: Health-Related Behaviors and Disease**
Gender Limited data shows more women drive motorcoach/bus than truck. **Race/ethnicity** Limited data shows a smaller percentage of white people drive motorcoach/bus than truck. **Age** Limited data shows the average age of motorcoach/bus drivers is slightly older than truck drivers: 48 and 43.7, respectively. **Income** Motorcoach/bus drivers tend make slightly less than truck drivers, although the disparity has lessened in the past 10 years. **Job Tenure** Motorcoach/bus drivers tend to have more years on the job than truck drivers.	**Roads travelled** Limited data shows that truck drivers spend more time on the interstate, and transit bus drivers spend more time driving time in the city. No data was available for coach drivers. **Distance travelled** Limited data shows truck drivers drive more miles per trip and week than coach drivers. **Driving time** Limited data shows bus drivers drive slightly fewer hours than truck drivers. No data was available for coach drivers.	**Scheduling/shift cycles** Limited data shows bus drivers tend to have more consistent schedules than truck drivers. No data was available for coach drivers. **Employment/industry culture** Limited data shows truck feel a slight more pressure to bend driving rules because of dispatchers; however, the difference is marginal. Limited data shows truck drivers have more personal motivations than coach drivers to continue driving when tired.	**Body Mass Index** Limited data shows the majority of truck and bus drivers are overweight or obese. The average BMI for both drivers is approximately 32.5 kg/m2. No data was available for coach drivers.

Demographics

Based on comparisons between coach/coach and truck drivers in Key Question 3A, our review found that motorcoach/bus drivers are more likely to be older, female, comprising more nonwhite drivers, earning less money, and having more experience.

The literature suggests that two key variables are likely to increase the risk for acute fatigue, placing motorcoach/bus drivers more at risk:

- **Older age:** (Di Milia et al., 2011[35]; Muecke, 2004[36]; and Nicholson, 1999[37])
- **Female gender:** (Tiesinga et al., 1999[38]; and Di Milia et al., 2011[35])

No other demographic variables were identified that would either increase or decrease the risk for acute fatigue for motorcoach/bus drivers when compared with truck drivers.

Job Function

Based on comparisons between motorcoach/bus and truck drivers in Key Question 3B, our review found that motorcoach/bus drivers are more likely to drive on city roads, fewer miles, and for slightly fewer hours. Despite these results, only one attribute (miles per day) represents coach drivers.

The literature suggests that exposure to three key variables is likely to increase the risk for acute fatigue, placing motorcoach/bus drivers at a decreased risk for acute fatigue when compared to truck drivers:

- **Monotonous driving conditions** (Eskandarian et al., 2007[39]; Lal and Craig, 2001[40]; and Williamson et al., 2011[41])
- **Long driving hours** (Caruso et al., 2004[42]; Duke et al., 2010[43]; Horne and Reyner, 1999[44]; and Lal and Craig, 2001[40])
- **Long work hours** (Eskandarian et al., 2007[39]; Lal and Craig, 2001[40]; Morrow and Crum, 2004[45]; Nicholson, 1999[37]; and Van der Hulst, 2003[46])

Bus drivers are more likely to drive on city roads, compared to truck drivers, who spend most of their time driving on the interstate. Monotonous work or driving conditions are factors for fatigue. Long-haul truck drivers, on average, drive more hours a day than straight- and split-shift bus drivers. Long work hours and long driving hours (Caruso et al., 2004[236], Duke et al., 2010[227], Horne and Reyner, 1999[237], and Lal and Craig, 2001[231]) have been linked to an increased risk for acute fatigue. Additionally, coach drivers, on average, drive half as many miles as truck drivers: 1,200 miles vs. 2,449 miles, placing truck drivers at an increased risk for acute fatigue.

Other job function variables identified that would either increase or decrease the risk for acute fatigue is:

- **Loading and unloading tasks** (Lal and Craig, 2001[40]; and Morrow and Crum, 2004[45]).

A literature review by Brock et al., 2005[153], which did not meet the inclusion criteria for Key Question 3, points out that coach drivers have the additional responsibility of helping with luggage, taking tickets, and generally looking after their passengers. While loading and unloading cargo has been suggested to improve alertness in the short-term by providing diversion and exercise, these effects are believed to wear off quickly and result in decreased driving performance after 12 hours of duty (Morrow and Crum[45]).

Work Environment

Based on our comparisons between motorcoach/bus and truck drivers in Key Question 3C, our review found that motorcoach/bus drivers are more likely to have more consistent scheduling and feel slightly less pressure from dispatchers to bend driving rules. Despite these results, only one attribute (dispatcher pressure) represents coach drivers.

Our literature review of fatigue risk factors in this section suggests that exposure to three key variables is likely to place motorcoach/bus drivers at a decreased risk for acute fatigue:

- **The pressure of making deliveries on time** (Morrow and Crum, 2004[45]).

Other work environment characteristics that are consistently associated with increased risk for acute fatigue include:

- **Shift work** (night work/irregular work hours, both of which interfere with the circadian rhythm) (Akerstedt et al., 2003[47]; Apostolopoulos et al., 2010[48]; Lal and Craig, 2001[40]; Leibowitz et al., 2006[49]; Morrow and Crum, 2004[45]; Muecke, 2004[36]; and Nicholson, 1999[37])
- **Sleep debt** (Akerstedt et al., 2003[47]; Apostolopoulos et al., 2010[48]; Duke et al., 2010[43]; Eskandarian et al., 2007[39]; Leibowitz et al., 2006[49]; Muecke, 2004[36]; Nicholson, 1999[37]; Niu et al., 2011[50]; Smolensky et al., 2011[51]; and Williamson et al., 2011[41])

Brock et al. identified the following qualitative differences between truck and coach drivers:

- Motorcoach seats do not provide comfortable areas for sleeping. Unlike many tractor-trailer trucks, buses rarely have sleeper berth areas for drivers. On the other hand, many coach drivers have the opportunity to sleep in hotel rooms while transporting tour groups.
- Whereas truck drivers can often drive the same hours every day or night, coach drivers are tied to various tour or commercial schedules. Inverted duty/sleep cycles (ie, driving during the day followed by a 24-hour break and then driving at night) can occur "because of group itineraries; also, itineraries may be spontaneously altered, disrupting the driver's planned schedule."
- Within the tour bus operator population, peak-season demands may reduce opportunities for extended rest periods.
- Coach drivers are in constant contact with their passengers. There are only marginal physical separations between the driver and his or her passengers' activities.

Health-Related Behaviors and Disease Characteristics

Based on comparisons between motorcoach/bus and truck drivers in Key Question 3D, our review found that motorcoach/bus drivers are as likely to be overweight or obese as truck drivers.

The literature suggests that obesity is a key variable to increase the risk for acute fatigue:

- **Obesity** (Duke et al., 2010[43]; Smolensky et al., 2011[51]; and Vgontzas et al., 2006[52])

The only health-related data available for both motorcoach/bus and truck drivers pertain to obesity. On average, both motorcoach/bus and truck drivers are overweight and/or obese, with an average BMI of 32.7 kg/m^2 (based on a single study) and 32.3 in kg/m^2 (based on eight studies), respectively, placing both groups at an increased risk for acute fatigue based on their BMI.

Other health-related characteristics that are consistently associated with increased risk for acute fatigue include:

- **Sleep apnea/Sleep-disordered breathing (**Duke et al., 2010[43]; Eskandarian et al., 2007[39]; Leibowitz et al., 2006[49]; Smolensky et al., 2011[51]; and Vgontzas et al., 2006[52])
- **Restless legs syndrome** (Leibowitz et al., 2006[49]; and Smolensky et al., 2011[51])
- **Diabetes** (Smolensky et al., 2011[51]; and Vgontzas et al., 2006[52])
- **Depression and/or anxiety** (Leibowitz et al., 2006[49]; Smolensky et al., 2011[51]; Tiesinga et al., 1999[38]; and Vgontzas et al., 2006[52])

A paucity of data for motorcoach/bus drivers, however, makes it difficult to examine whether they are at an increased (or decreased) risk for acute fatigue based on differences between these health-related variables.

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Appendix A: Search Summaries

Key Question 1A: Crash

PUBMED

Set Number	Concept	Search Statement	Number Identified
1	Acute fatigue/Fatigue	(((("fatigue"[MeSH Terms] OR "fatigue"[All Fields]) OR (acute[All Fields] AND ("fatigue"[MeSH Terms] OR "fatigue"[All Fields]))) OR ("sleep deprivation"[MeSH Terms] OR ("sleep"[All Fields] AND "deprivation"[All Fields]) OR "sleep deprivation"[All Fields])) OR (("sleep"[MeSH Terms] OR "sleep"[All Fields]) AND restriction[All Fields])) OR (("sleep"[MeSH Terms] OR "sleep"[All Fields]) AND curtailment[All Fields]) AND (("1965/01/01"[PDAT] : "2012/05/21"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])	66,358
2	Direct Crash Risk	((((((((((("accidents"[MeSH Terms] OR "accidents"[All Fields] OR "accident"[All Fields]) OR ("accident prevention"[MeSH Terms] OR ("accident"[All Fields] AND "prevention"[All Fields]) OR "accident prevention"[All Fields])) OR ("accidents"[MeSH Terms] OR "accidents"[All Fields])) OR ("accidents, traffic"[MeSH Terms] OR ("accidents"[All Fields] AND "traffic"[All Fields]) OR "traffic accidents"[All Fields] OR ("traffic"[All Fields] AND "accidents"[All Fields]))) OR ("accidents, occupational"[MeSH Terms] OR ("accidents"[All Fields] AND "occupational"[All Fields]) OR "occupational accidents"[All Fields] OR ("occupational"[All Fields] AND "accidents"[All Fields]))) OR (highway[All Fields] AND ("safety"[MeSH Terms] OR "safety"[All Fields]))) OR (motor[All Fields] AND ("accidents, traffic"[MeSH Terms] OR ("accidents"[All Fields] AND "traffic"[All Fields]) OR "traffic accidents"[All Fields] OR ("traffic"[All Fields] AND "accidents"[All Fields])))) OR crash[All Fields]) OR wreck[All Fields]) OR collision[All Fields]) OR ("accidents, traffic"[MeSH Terms] OR ("accidents"[All Fields] AND "traffic"[All Fields]) OR "traffic accidents"[All Fields] OR ("traffic"[All Fields] AND "accident"[All Fields]) OR "traffic accident"[All Fields])) OR (("transportation"[MeSH Terms] OR "transportation"[All Fields]) AND ("accidents"[MeSH Terms] OR "accidents"[All Fields] OR "accident"[All Fields]))) OR (("Traffic"[Journal] OR "traffic"[All Fields]) AND ("safety"[MeSH Terms] OR "safety"[All Fields]))	174,520
3	Driving	((((((((((("drive"[MeSH Terms] OR "drive"[All Fields]) OR ("automobile driving"[MeSH Terms] OR ("automobile"[All Fields] AND "driving"[All Fields]) OR "automobile driving"[All Fields] OR "driving"[All Fields])) OR ("automobiles"[MeSH Terms] OR "automobiles"[All Fields] OR "automobile"[All Fields])) OR ("automobiles"[MeSH Terms] OR "automobiles"[All Fields] OR "car"[All Fields])) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "truck"[All Fields])) OR tractor-trailer[All Fields]) OR (commercial[All Fields] AND ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR ("motor"[All Fields] AND "vehicle"[All Fields]) OR "motor vehicle"[All Fields]))) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "lorry"[All Fields])) OR bus[All Fields]) OR (motor[All Fields] AND coach[All Fields])) OR (public[All Fields] AND ("transportation"[MeSH Terms] OR "transportation"[All Fields]))) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All	185,772

Set Number	Concept	Search Statement	Number Identified
		Fields] OR ("motor"[All Fields] AND "vehicle"[All Fields]) OR "motor vehicle"[All Fields])	
4	Combine	#2 AND #3	21,332
5	Combine	#1 AND #4	441
6	Limit	(#61) AND #52 AND (("1965/01/01"[PDAT] : "2012/05/21"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])	370

Searched through 6/10/2012

CINAHL Statements

Set Number	Concept	Search Statement	Number Identified
1	Fatigue (acute)	MH "Fatigue" OR fatigue OR sleepiness OR exhaustion OR tiredness OR drowsiness	41,206
2	Driving	MH "Vehicle Operation" OR MH "Automobile Driving" OR MH "Motor Vehicles" OR MH "Transportation" OR vehicle OR vehicles OR car OR cars OR bus OR buses OR truck OR trucks OR motor vehicle OR (motor AND vehicle)	38,615
3	Crash Risk	(MH "Accidents") OR (MH "Accidents, Traffic") OR (MH "Accidents, Occupational") OR (MH "Accidents, Aviation") OR (MH "Safety") OR (MH "Transportation") OR accident OR accidents OR (accident AND prevention) OR accident prevention OR traffic OR (traffic and accident) OR (traffic AND accidents) OR occupational OR (occupational AND accident) OR (occupational AND accidents) OR occupational accidents OR wreck OR collision OR collide OR traffic accident OR traffic accidents OR transportation	248,380
4	Combine	Set 1 & Set 2	691
5	Combine	Set 3 & Set 4	454
6	Limits	English Language	426

Searched through 6/15/2012

Psych Statements

Set Number	Concept	Search Statement	Number Identified
1	Fatigue (acute)	((DE "Sleepiness" OR MM "Fatigue")) OR (DE "Fatigue") OR fatigue OR sleepiness OR exhaustion OR tiredness OR drowsiness	41,206
2	Driving	((MM "Drivers" OR MM "Automobiles" OR MM "Driving Behavior" OR MM "Highway Safety" OR MM "Motor Traffic Accidents" OR MM "Motor Vehicles") OR (DE "Ground Transportation" OR MM "Transportation" OR MM "Air Transportation" OR MM "Ground Transportation" OR MM "Public Transportation" OR MM "Water Transportation") OR BUSES OR MOTORCYCLES OR TRUCKS)	14,476
3	Crash Risk	(DE "Accident Prevention") OR (DE "Accident Proneness") OR (DE "Accidents") OR (DE "Motor Traffic Accidents") OR (DE "Occupational Safety") OR (DE "Injuries") OR (DE "Safety") OR accident OR accidents OR (accident AND prevention) OR accident prevention OR traffic OR (traffic and accident) OR (traffic AND accidents) OR occupational OR (occupational AND accident) OR (occupational AND accidents) OR occupational accidents OR wreck OR collision OR collide OR traffic accident OR traffic accidents OR transportation	259,394
4	Combine	Set 1 & Set 2	551

Set Number	Concept	Search Statement	Number Identified
5	Combine	Set 3 & Set 4	447
6	Limits	English Language	421

Searched through 6/15/2012

The Cochrane Library

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	#2 OR fatigue OR sleepiness OR exhaustion OR tiredness OR drowsiness	12,554
2	Driving	#3 OR #10	715
3	Crash Risk	#2 OR #3 OR accident OR accidents OR (accident AND prevention) OR accident prevention OR traffic OR (traffic and accident) OR (traffic AND accidents) OR occupational OR (occupational AND accident) OR (occupational AND accidents) OR occupational accidents OR wreck OR collision OR collide OR traffic accident OR traffic accidents OR transportation	7,407
4	Combine	Sets 1 and 2	77
5	Combine	Sets 3 and 4	30

Searched through Issue 8, 2012

TRID

Set Number	Concept	Search Statement	Number Identified
1	Acute fatigue/Fatigue	Fatig*	19,555
2	Crash	Cras*	25,000
3	Combine	#1 AND #2	3,153
4	Limit	English only	2,810
6	Retrieved		21

Searched through 6/10/2012

Key Question 1B: Driving Ability

PUBMED

Set Number	Concept	Search Statement	Number Identified
1	Acute fatigue/Fatigue	(((("fatigue"[MeSH Terms] OR "fatigue"[All Fields]) OR (acute[All Fields] AND ("fatigue"[MeSH Terms] OR "fatigue"[All Fields]))) OR ("sleep deprivation"[MeSH Terms] OR ("sleep"[All Fields] AND "deprivation"[All Fields]) OR "sleep deprivation"[All Fields])) OR (("sleep"[MeSH Terms] OR "sleep"[All Fields]) AND restriction[All Fields])) OR (("sleep"[MeSH Terms] OR "sleep"[All Fields]) AND curtailment[All Fields]) AND (("1965/01/01"[PDAT] : "2012/05/21"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])	66,358
2	Driving	(((((((((("drive"[MeSH Terms] OR "drive"[All Fields]) OR ("automobile driving"[MeSH Terms] OR ("automobile"[All Fields] AND "driving"[All Fields]) OR "automobile driving"[All Fields] OR "driving"[All Fields])) OR ("automobiles"[MeSH Terms] OR "automobiles"[All Fields] OR "automobile"[All Fields])) OR ("automobiles"[MeSH Terms] OR "automobiles"[All Fields] OR "car"[All Fields])) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "truck"[All Fields])) OR tractor-trailer[All Fields]) OR	185,772

Set Number	Concept	Search Statement	Number Identified
		(commercial[All Fields] AND ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR ("motor"[All Fields] AND "vehicle"[All Fields]) OR "motor vehicle"[All Fields]))) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "lorry"[All Fields])) OR bus[All Fields]) OR (motor[All Fields] AND coach[All Fields])) OR (public[All Fields] AND ("transportation"[MeSH Terms] OR "transportation"[All Fields]))) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR ("motor"[All Fields] AND "vehicle"[All Fields]) OR "motor vehicle"[All Fields])	
3	Combine	#1 AND #2	1,848
4	Limit	(#53) AND #52 AND (("1965/01/01"[PDAT] : "2012/05/21"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])	1,368

CINAHL Statements

Set Number	Concept	Search Statement	Number Identified
1	Fatigue (acute)	MH "Fatigue" OR fatigue OR sleepiness OR exhaustion OR tiredness OR drowsiness	41,206
2	Driving	MH "Vehicle Operation" OR MH "Automobile Driving" OR MH “Motor Vehicles” OR MH "Transportation" OR vehicle OR vehicles OR car OR cars OR bus OR buses OR truck OR trucks OR motor vehicle OR (motor AND vehicle)	38,615
3	Combine	Set 1 and Set 2	637
4	Limits	English Language	595

Psych Statements

Set Number	Concept	Search Statement	Number Identified
1	Fatigue (acute)	((DE "Sleepiness" OR MM "Fatigue")) OR (DE "Fatigue") OR fatigue OR sleepiness OR exhaustion OR tiredness OR drowsiness	41,206
2	Driving	((MM "Drivers" OR MM "Automobiles" OR MM "Driving Behavior" OR MM "Highway Safety" OR MM "Motor Traffic Accidents" OR MM "Motor Vehicles") OR (DE "Ground Transportation" OR MM "Transportation" OR MM "Air Transportation" OR MM "Ground Transportation" OR MM "Public Transportation" OR MM "Water Transportation") OR BUSES OR MOTORCYCLES OR TRUCKS)	14,476
3	Combine	Set 1 and Set 2	547
4	Limits	English Language	514

The Cochrane Library

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	#2 OR fatigue OR sleepiness OR exhaustion OR tiredness OR drowsiness	12,554
2	Driving	#3 OR #10	715
3	Combine	Set 1 and 2	77

TRID

Set Number	Concept	Search Statement	Number Identified
1	Acute fatigue/Fatigue	Fatig*	19,555
2	Driving	Driv*	25,000
3	Combine	#1 AND #2	3153

Key Question 2

PUBMED

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	"asthenia"[MeSH Terms] OR "asthenia"[All Fields] OR "fatigue"[MeSH Terms] OR "fatigue"[All Fields] OR "lethargy"[MeSH Terms] OR "lethargy"[All Fields] OR "mental fatigue"[MeSH Terms] OR ("mental"[All Fields] AND "fatigue"[All Fields]) OR "mental fatigue"[All Fields] OR "sleep deprivation"[MeSH Terms] OR ("sleep"[All Fields] AND "deprivation"[All Fields]) OR "sleep deprivation"[All Fields] OR "sleep disorders"[MeSH Terms] OR ("sleep"[All Fields] AND "disorders"[All Fields]) OR "sleep disorders"[All Fields] OR "alertness"[All Fields] OR "driving fatigue"[All Fields] OR "drowsiness"[All Fields] OR "drowsy"[All Fields] OR "ennui"[All Fields] OR "exhaustion"[All Fields] OR "faint*"[All Fields] OR "languor"[All Fields] OR "lethargy"[All Fields] OR "lassitude"[All Fields] OR "listless*"[All Fields] OR ("mental*"[All Fields] AND "alert*"[All Fields]) OR "overwork*"[All Fields] OR "overburden*"[All Fields] OR "overtax*"[All Fields] OR "overspend*"[All Fields] OR "overstrain*"[All Fields] OR ("sleep"[All Fields] AND "restrict*"[All Fields]) OR "sleepiness"[All Fields] OR "sleepy"[All Fields] OR "sluggish*"[All Fields] OR "tired*"[All Fields] OR "weary"[All Fields] OR "weariness"[All Fields] OR "worn out"[All Fields] OR "yawn*"[All Fields]	154,521
2	Driving/Operating Vehicle/Piloting/Conducting	"automobile driving"[MeSH Terms] OR ("automobile"[All Fields] AND "driving"[All Fields]) OR "motor vehicles"[MeSH Terms] OR (“motor”[All Fields] AND “vehicle*”[All Fields]) OR "automobile driving"[All Fields] OR "driving"[All Fields]) OR ("driver*"[All Fields]) OR ("operat*"[All Fields] AND "vehicle*"[All Fields]) OR "pilot*"[All Fields] OR "conduct*"[All Fields] OR "ship*"[All Fields] OR "fly*"[All Fields]	232,711
3	Specific Driver Type		
	Professional commercial motor vehicle drivers	"big rig*" OR "big truck*" OR "bus" OR "buses" OR "cab over*" OR "carrier*" OR "coach*" OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR "company driver*" OR "CMV*" OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR "lorries" OR "lorry" OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi-trailer*" OR "semi trailer*" OR "semi-truck*" OR "semi truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR "trucker*"	208,617
	All Professional Drivers:	"big rig*" OR "big truck*" OR "bus" OR "buses" OR "cab over*" OR "carrier*" OR "coach*" OR "combination vehicle*" OR	316,189

Set Number	Concept	Search Statement	Number Identified
		"commercial motor vehicle driver*" OR "commercial driv*" OR "company driver*" OR "CMV*" OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR "lorries" OR "lorry" OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi-trailer*" OR "semi trailer*" OR "semi-truck*" OR "semi truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR "trucker*"OR "cabbie*" OR "captain*" OR "chauffer*" OR "conductor*" OR "pilot*" OR "train operator*" OR "railway operator*" OR "professional driver*" OR ("public transportation*" AND "driver*")	
	General Public Maybe add “driver”?	NO SEARCH STATEMENT NEEDED	N/A
4	Rest to recovery:	"rest" [MESH] OR "rest" OR "recovery" OR "sleep" [MESH] OR "sleep" OR "nap" OR "naps" OR "napping" OR "function*" OR ("driving" AND "abilit*")	1,782,028
5	Combination: Fatigue & driving/vehicle operating	#1 & #2	4,630
For commercial motor vehicle drivers:			
6a	Combination: Fatigue, driving/vehicle operating, & commercial motor vehicle drivers	#5 & # 3a	161
6b	Combination: Fatigue, driving/vehicle operation, commercial motor vehicle drivers, & rest to recovery	#6a & #4	101
For all professional drivers:			
7	Combination: Fatigue, driving/vehicle operation, & all professional drivers	#5 & #3b	2,454
8	Combination: Fatigue, driving/vehicle operation, all professional drivers, & rest to recovery	#7 & #4	1,297 (Screened)
For general public:			
9	Combination: Fatigue, driving/vehicle operation, & rest to recovery	#5 & #4	2,656

Searched through 6/13/2012

CINAHL & PSYCHINFO Combined Searches, PsychInfo statements

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	(DE "Asthenia") OR asthenia OR (DE "Fatigue") OR fatigue OR lethargy OR "mental fatigue" OR (DE "Sleep Deprivation") OR (sleep AND deprivation) OR "sleep disorder*" OR alertness OR "driving fatigue" OR drowsy OR drowsiness OR ennui OR exhaustion OR ((faint* OR languor OR lethargy OR lassitude OR listless* OR ((mental*) AND (alert*)) OR overwork* OR overburden* OR overtax* OR overspend* OR overstrain* OR ((sleep) AND (restrict*))) OR (DE "Sleepiness") OR sleepiness OR sleepy OR sluggish* OR tired* OR weary	73,908

Set Number	Concept	Search Statement	Number Identified
		OR weariness OR "worn out") OR (DE "Yawning")	
2	Driving/Operating Vehicle/Piloting	(DE "Motor Vehicles" OR DE "Drivers") OR (DE "Railroad Trains") OR (DE "Driving Behavior") OR driv* OR operat* OR pilot* OR conduct* OR ship* OR fly* OR captain* OR (motor AND vehicle*)	610,537
3	Specific Driver Type		
	Professional commercial motor vehicle drivers	truck* OR "big rig*" OR bus OR buses OR "cab over*" OR carrier* OR coach* OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR "company driver*" OR CMV* OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR lorries OR lorry OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi trailer*" OR "semi-trailer*" OR "semi truck*" OR "semi-truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR "trucker*"truck* OR "big rig*" OR bus OR buses OR "cab over*" OR carrier* OR coach* OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR "company driver*" OR CMV* OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR lorries OR lorry OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi trailer*" OR "semi-trailer*" OR "semi truck*" OR "semi-truck*" OR "tractor-trailer*	38,128
	All Professional Drivers	truck* OR "big rig*" OR bus OR buses OR "cab over*" OR carrier* OR coach* OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR "company driver*" OR CMV* OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR lorries OR lorry OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi trailer*" OR "semi-trailer*" OR "semi truck*" OR "semi-truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR "trucker*" OR (((cabbie* OR captain* OR chauffer* OR conductor* OR pilot*) OR (DE "Aircraft Pilots") OR "train operator*" OR "railway operator*") OR "professional driver*") OR ((DE "Public Transportation") and driv*)	109,453
	General Public	NO SEARCH STATEMENT NEEDED	
4	Rest to recovery	rest OR recovery OR (DE "Sleep") OR (DE "Napping") OR sleep* OR nap OR naps OR napping OR function* OR (DE "Driving Behavior") OR (driv* AND abilit*)	737,950
5	Combination: Fatigue & driving/vehicle operating	#1 & #2	10,055
For commercial motor vehicle drivers:			
6a	Combination: Fatigue, driving/vehicle operating, & commercial motor vehicle drivers	#5 & # 3a	309
6b	Combination: Fatigue, driving/vehicle operation, commercial motor vehicle drivers, & rest to recovery	#6a & #4	226
For all professional drivers:			

Set Number	Concept	Search Statement	Number Identified
7	Combination: Fatigue, driving/vehicle operation, & all professional drivers	#5 & #3b	1,967
8	Combination: Fatigue, driving/vehicle operation, all professional drivers, & rest to recovery	#7 & #4	1,128 (Screened)
For general public:			
9	Combination: Fatigue, driving/vehicle operation, & rest to recovery	#5 & #4	5,724

Searched through 6/15/2012

CINAHL & PSYCHINFO Combined Searches, CINAHL statements

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	(MH "Asthenia") OR "asthenia" OR (MH "Fatigue+") OR "fatigue" OR "lethargy" OR "mental fatigue" OR (MH "Sleep Deprivation") OR "sleep deprivation" OR (MH "Sleep Disorders, Circadian Rhythm") OR (MH "Sleep Disorders+") OR "alertness" OR "driving fatigue" OR "drowsiness" OR "drowsy" OR "ennui" OR "exhaustion" OR "faint*" OR "languor" OR "lethargy" OR "lassitude" OR "listless*" OR "overwork" OR "overburden" OR "overburden*" OR "overtax*" OR "overspend*" OR "overwork*" OR "overstrain*" OR (“sleep” AND “restrict*”) OR "sleepiness" OR "sleepy" OR "sluggish*" OR "tired*" OR "weary" OR "weariness" OR "worn out" OR (MH "Yawning") OR "yawn*"	73,999
2	Driving/Operating Vehicle/Piloting	"driv*" OR (MH "Vehicle Operation+") OR (MH "Motor Vehicles+") OR ("motor" AND "vehicle*") OR (“operat*” AND “vehicle*”) OR ((MH "Pilots") OR "pilot*" OR "conduct*" OR (MH "Ships+") OR "ship*" OR “fly*”	466,931
3	Specific Driver Type		
	a. Professional commercial motor vehicle drivers	"big rig*" OR "big truck*" OR "bus" OR "buses" OR "cab over*" OR "carrier*" OR "coach*" OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR "company driv*" OR "company driver*" OR "CMV*" OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR "lorries" OR "lorry" OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi-trailer*" OR "semi trailer*" OR "semi-truck*" OR "semi truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR "trucker*"	37,205
	b. All Professional Drivers	"big rig*" OR "big truck*" OR "bus" OR "buses" OR "cab over*" OR "carrier*" OR "coach*" OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR "company driv*" OR "company driver*" OR "CMV*" OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR "haul*" OR "large truck*" OR "long distance*" OR "lorries" OR "lorry" OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi-trailer*" OR "semi trailer*" OR "semi-truck*" OR "semi truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR "trucker*" OR (MH "Vehicle Operation+") OR "vehicle operation" OR "cabbie*" OR "captain*" OR "chauffer*" OR "conductor*" OR (MH "Pilots") OR "pilot*" OR "train operator*" OR (MH "Railroads") OR "railway operator*" OR "professional driver*" OR ("public transportation" AND "driver*")	113,225
	c. General Public	NO SEARCH STATEMENT NEEDED	N/A

Set Number	Concept	Search Statement	Number Identified
4	Rest to recovery	"rest" OR (MH "Psychological Processes and Principles") OR (MH "Sleep+") OR (MH "Recovery") OR "recovery" OR "nap" OR "naps" OR "napping" OR "function*" OR ("driving" AND "abilit*")	675,154
5	Combination: Fatigue & driving/vehicle operating	#1 & #2	8,109
For commercial motor vehicle drivers:			
6a	Combination: Fatigue, driving/vehicle operating, & commercial motor vehicle drivers	#5 & # 3a	275
6b	Combination: Fatigue, driving/vehicle operation, & commercial motor vehicle drivers, rest to recovery	#6a & #4	101
For all professional drivers:			
7	Combination: Fatigue, driving/vehicle operation, & all professional drivers	#5 & #3b	2,179
8	Combination: Fatigue, driving/vehicle operation, all professional drivers, & rest to recovery	#7 & #4	768 (Reviewed)
For general public:			
9	Combination: Fatigue, driving/vehicle operation, & rest to recovery	#5 & #4	2,589

Searched through 6/15/2012

The Cochrane Library

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	asthenia OR fatigue OR lethargy OR alertness OR drowsiness OR drowsy OR ennui OR exhaustion OR faint* OR languor OR lethargy OR lassitude OR listless* OR overwork* OR overburden* OR overtax* OR overspend* OR overstrain* OR sleepiness OR sleepy OR sluggish* OR tired* OR weary OR weariness OR "worn out" OR yawn* OR (mental AND fatigue) OR (sleep AND disorders) OR (driving AND fatigue) OR (mental AND alert*) OR (sleep AND restrict*) OR "worn out"	18,604
2	Driving/Operating Vehicle/Piloting	driv* OR (operat* AND vehicle*) OR pilot* OR conduct* OR ship* OR fly* OR (motor AND vehicle*)	83,369
3	Specific Driver Type		
	Professional commercial motor vehicle drivers	"big rig*" OR "big truck*" OR bus OR buses OR "cab over*" OR carrier* OR coach* OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR CMV* OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR haul* OR "large truck*" OR "long distance*" OR lorries OR lorry OR "motor coach driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi-trailer*" OR "semi trailer*" OR "semi-truck*" OR "semi truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR trucker*	4,955
	All Professional Drivers	"big rig*" OR "big truck*" OR bus OR buses OR "cab over*" OR carrier* OR coach* OR "combination vehicle*" OR "commercial motor vehicle driver*" OR "commercial driv*" OR CMV* OR "contract carrier*" OR "conventional truck*" OR "day cab*" OR haul* OR "large truck*" OR "long distance*" OR lorries OR lorry OR "motor coach	24,327

Set Number	Concept	Search Statement	Number Identified
		driver*" OR "over-the-road" OR "owner-operator*" OR "private carrier*" OR "semi-trailer*" OR "semi trailer*" OR "semi-truck*" OR "semi truck*" OR "tractor-trailer*" OR "tractor trailer*" OR "truck driver*" OR trucker* OR cabbie* OR captain* OR chauffer* OR conductor* OR pilot* OR "train operator*" OR "railway operator*" OR "professional driver*" OR ("public transportation" AND driver*)	
	General Public	NO SEARCH STATEMENT NEEDED	N/A
4	Rest to recovery	rest OR recovery OR sleep OR nap OR naps OR napping OR function* OR (driving AND abilit*)	118,363
5	Combination: Fatigue & driving/vehicle operating	#1 & #2	4,658
For commercial motor vehicle drivers:			
6	Combination: Fatigue, driving/vehicle operating, & commercial motor vehicle drivers	#5 & # 3a	229
7	Combination: Fatigue, driving/vehicle operation, commercial motor vehicle drivers, & rest to recovery	#6 & #5	202
For all professional drivers:			
7	Combination: Fatigue, driving/vehicle operation, & all professional drivers	#5 & #3b	1,731
8	Combination: Fatigue, driving/vehicle operation, all professional drivers, & rest to recovery	#7 & #4	1,396 (Screened)
For general public:			
9	Combination: Fatigue, driving/vehicle operation, & rest to recovery	#5 & #4	3,376

Searched through 6/21/2012

TRID

Set Number	Concept	Search Statement	Number Identified
1	Fatigue	fatigue* OR sleep* OR drows* OR asthenia OR exhaustion	22,283
2	Driving/Operating Motor	driv* OR (operat* AND vehicle*) OR pilot* OR conduct* OR	>25,000

Set Number	Concept	Search Statement	Number Identified
	Vehicle/Piloting	ship* OR fly* OR (motor AND vehicle*)	
3	Specific Driver Type		
	Professional commercial motor vehicle drivers	"commercial motor vehicle driver" OR "commercial motor vehicle drivers" OR trucker* OR "truck driver" OR "truck drivers" OR "motor coach driver" OR "motor coach drivers" OR (semi* AND driver*) OR CMV* OR (tractor* AND trailer*)	11,935
	All Professional Drivers	"commercial motor vehicle driver" OR "commercial motor vehicle drivers" OR trucker* OR "truck driver" OR "truck drivers" OR "motor coach driver" OR "motor coach drivers" OR (semi* AND driver*) OR CMV* OR (tractor* AND trailer*) OR cabbie* OR captain* OR chauffer* OR conductor* OR pilot* OR "train operator*" OR "railway operator*" OR "professional driver*" OR ("public transportation" AND driver*)	>25,000
	General Public	NO SEARCH STATEMENT NEEDED	
4	Rest to recovery	rest OR recovery OR sleep OR nap OR naps OR napping OR function* OR (driving AND abilit*)	>25,000
5	Combination: Fatigue & driving/vehicle operating	#1 & #2	8,080
For commercial motor vehicle drivers:			
6	Combination: Fatigue, driving/vehicle operating, & commercial motor vehicle drivers	#5 & # 3a	942
7	Combination: Fatigue, driving/vehicle operating, & commercial motor vehicle drivers, & rest to recovery	#6 & #4	509
For all professional drivers:			
8	Combination: Fatigue, driving/vehicle operation, & all professional drivers	#5 & #3b	1578
8	Combination: Fatigue, driving/vehicle operation, all professional drivers, & rest to recovery	#8 & #4	767
For general public:			
9	Combination: Fatigue, driving/vehicle operation, & rest to recovery	#5 & #4	2,135

Searched through 6/21/2012

Key Question 3A: Demographics

PubMed, TRIS, Virginia Tech Transportation Institute

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
1	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,471	05/24/2012
2	Gender PubMed	("sex distribution"[MeSH Terms] OR ("sex"[All Fields] AND "distribution"[All Fields]) OR "sex distribution"[All Fields]) OR ("sex ratio"[MeSH Terms] OR ("sex"[All Fields] AND "ratio"[All Fields]) OR "sex ratio"[All Fields]) OR ("gender identity"[MeSH Terms] OR ("gender"[All Fields] AND "identity"[All Fields]) OR "gender identity"[All Fields] OR "gender"[All Fields]) OR ("sex"[MeSH Terms] OR "sex"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	444,246	05/24/2012
3	Combine	#1 and #2	1,066	05/24/2012
4	Demography PubMed	("demography"[MeSH Terms] OR "demography"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	646,100	05/24/2012
5	Combine	#2 and #4	116,393	05/24/2012
6	Commercial motor vehicles PubMed	("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields]) OR (big[All Fields] AND ("Rig"[Journal] OR "rig"[All Fields])) OR (big[All Fields] AND rigs[All Fields]) OR bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "cab over"[All Fields] OR "combination vehicle"[All Fields] OR (combination[All Fields] AND vehicles[All Fields]) OR (conventional[All Fields] AND ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "truck"[All Fields])) OR (conventional[All Fields] AND ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "trucks"[All Fields])) OR CMV[All Fields] OR (commercial[All Fields] AND driv[All Fields]) OR "commercial motor vehicle"[All Fields] OR "commercial motor vehicles"[All Fields] OR (day[All Fields] AND cab[All Fields]) OR (day[All Fields] AND cabs[All Fields]) OR haul[All Fields] OR "large truck"[All Fields] OR "large trucks"[All Fields] OR "long distance"[All Fields] OR lorries[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "lorry"[All Fields]) OR (professional[All Fields] AND driv[All Fields]) OR semi-trailer[All Fields] OR semi-trailers[All Fields] OR tractor-trailer[All Fields] OR tractor-trailers[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "truck"[All Fields]) OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "trucks"[All Fields]) OR vehicle[All Fields] OR vehicles[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	53,708	05/24/2012
7	Combine	#5 and #6	1,345	05/24/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
8	Race/ethnicity PubMed	("african americans"[MeSH Terms] OR ("african"[All Fields] AND "americans"[All Fields]) OR "african americans"[All Fields]) OR ("asian americans"[MeSH Terms] OR ("asian"[All Fields] AND "americans"[All Fields]) OR "asian americans"[All Fields]) OR ("european continental ancestry group"[MeSH Terms] OR ("european"[All Fields] AND "continental"[All Fields] AND "ancestry"[All Fields] AND "group"[All Fields]) OR "european continental ancestry group"[All Fields]) OR ("ethnic groups"[MeSH Terms] OR ("ethnic"[All Fields] AND "groups"[All Fields]) OR "ethnic groups"[All Fields]) OR "Hispanic American"[All Fields] OR "Hispanic Americans"[All Fields] OR "Mexican American"[All Fields] OR "Mexican Americans"[All Fields] OR "Black"[All Fields] OR "Blacks"[All Fields] OR "Caucasian"[All Fields] OR "Caucasians"[All Fields] OR "Cuban American"[All Fields] OR "Cuban Americans"[All Fields] OR ("hispanic americans"[MeSH Terms] OR ("hispanic"[All Fields] AND "americans"[All Fields]) OR "hispanic americans"[All Fields] OR "hispanic"[All Fields]) OR ("hispanic americans"[MeSH Terms] OR ("hispanic"[All Fields] AND "americans"[All Fields]) OR "hispanic americans"[All Fields] OR "hispanics"[All Fields]) OR Indian[All Fields] OR Indians[All Fields] OR ("hispanic americans"[MeSH Terms] OR ("hispanic"[All Fields] AND "americans"[All Fields]) OR "hispanic americans"[All Fields] OR "latino"[All Fields]) OR ("hispanic americans"[MeSH Terms] OR ("hispanic"[All Fields] AND "americans"[All Fields]) OR "hispanic americans"[All Fields] OR "latinos"[All Fields]) OR ("hispanic americans"[MeSH Terms] OR ("hispanic"[All Fields] AND "americans"[All Fields]) OR "hispanic americans"[All Fields] OR "latina"[All Fields]) OR ("hispanic americans"[MeSH Terms] OR ("hispanic"[All Fields] AND "americans"[All Fields]) OR "hispanic americans"[All Fields] OR "latinas"[All Fields]) OR Mexican[All Fields] OR Mexicans[All Fields] OR ("ethnic groups"[MeSH Terms] OR ("ethnic"[All Fields] AND "groups"[All Fields]) OR "ethnic groups"[All Fields] OR "nationality"[All Fields]) OR ("ethnic groups"[MeSH Terms] OR ("ethnic"[All Fields] AND "groups"[All Fields]) OR "ethnic groups"[All Fields] OR "nationalities"[All Fields]) OR "Native American"[All Fields] OR "Native Americans"[All Fields] OR "Puerto Rican"[All Fields] OR "Puerto Ricans"[All Fields] OR "Spanish American"[All Fields] OR "Spanish Americans"[All Fields] OR ("european continental ancestry group"[MeSH Terms] OR ("european"[All Fields] AND "continental"[All Fields] AND "ancestry"[All Fields] AND "group"[All Fields]) OR "european continental ancestry group"[All Fields] OR "white"[All Fields]) OR ("european continental ancestry group"[MeSH Terms] OR ("european"[All Fields] AND "continental"[All Fields] AND "ancestry"[All Fields] AND "group"[All Fields]) OR "european continental ancestry group"[All Fields] OR "whites"[All Fields]) OR ("ethnology"[Subheading] OR "ethnology"[All Fields] OR "ethnicity"[All Fields] OR "ethnology"[MeSH Terms] OR "ethnicity"[All Fields] OR "ethnic groups"[MeSH Terms] OR ("ethnic"[All Fields] AND "groups"[All Fields]) OR "ethnic groups"[All Fields]) OR ethnicities[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	378,709	05/25/2012
9	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,474	05/25/2012
10	Combine	#8 and #9	498	05/25/2012
11	Age	("age factors"[MeSH Terms] OR ("age"[All Fields] AND "factors"[All Fields]) OR "age factors"[All Fields]) OR ("age distribution"[MeSH Terms] OR ("age"[All Fields] AND "distribution"[All Fields]) OR "age distribution"[All Fields]) OR ("age	4,971,567	05/25/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
	PubMed	groups"[MeSH Terms] OR ("age"[All Fields] AND "groups"[All Fields]) OR "age groups"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])		
12	Demography PubMed	("demography"[MeSH Terms] OR "demography"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	646,277	05/25/2012
13	Combine	#11 and #12	506,142	05/25/2012
14	Combine	#9 and #13	1,389	05/25/2012
15	Eliminate duplicates	#14 not #10	1,243	05/25/2012
16	Socioeconomic factors PubMed	("career mobility"[MeSH Terms] OR ("career"[All Fields] AND "mobility"[All Fields]) OR "career mobility"[All Fields]) OR ("educational status"[MeSH Terms] OR ("educational"[All Fields] AND "status"[All Fields]) OR "educational status"[All Fields]) OR ("income"[MeSH Terms] OR "income"[All Fields]) OR ("poverty"[MeSH Terms] OR "poverty"[All Fields]) OR ("salaries and fringe benefits"[MeSH Terms] OR ("salaries"[All Fields] AND "fringe"[All Fields] AND "benefits"[All Fields]) OR "salaries and fringe benefits"[All Fields]) OR ("social class"[MeSH Terms] OR ("social"[All Fields] AND "class"[All Fields]) OR "social class"[All Fields]) OR ("socioeconomic factors"[MeSH Terms] OR ("socioeconomic"[All Fields] AND "factors"[All Fields]) OR "socioeconomic factors"[All Fields]) OR ("social class"[MeSH Terms] OR ("social"[All Fields] AND "class"[All Fields]) OR "social class"[All Fields] OR ("socioeconomic"[All Fields] AND "status"[All Fields]) OR "socioeconomic status"[All Fields]) OR ("education"[Subheading] OR "education"[All Fields] OR "educational status"[MeSH Terms] OR ("educational"[All Fields] AND "status"[All Fields]) OR "educational status"[All Fields] OR "education"[All Fields] OR "education"[MeSH Terms]) OR "income distribution"[All Fields] OR "income inequality"[All Fields] OR "low income"[All Fields] OR "low-income"[All Fields] OR "middle class population"[All Fields] OR "pay equity"[All Fields] OR ("salaries and fringe benefits"[MeSH Terms] OR ("salaries"[All Fields] AND "fringe"[All Fields] AND "benefits"[All Fields]) OR "salaries and fringe benefits"[All Fields] OR "salary"[All Fields]) OR ("economics"[Subheading] OR "economics"[All Fields] OR "salaries"[All Fields] OR "salaries and fringe benefits"[MeSH Terms] OR ("salaries"[All Fields] AND "fringe"[All Fields] AND "benefits"[All Fields]) OR "salaries and fringe benefits"[All Fields]) OR "standard of living"[All Fields] OR ("salaries and fringe benefits"[MeSH Terms] OR ("salaries"[All Fields] AND "fringe"[All Fields] AND "benefits"[All Fields]) OR "salaries and fringe benefits"[All Fields] OR "wages"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	893,062	05/27/2012
17	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,478	05/27/2012
18	Combine	#16 and #17	2,475	05/27/2012
19	Marital status	("divorce"[MeSH Terms] OR "divorce"[All Fields]) OR ("marital status"[MeSH Terms] OR ("marital"[All Fields] AND "status"[All	621,481	05/28/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
	PubMed	Fields]) OR "marital status"[All Fields]) OR ("marriage"[MeSH Terms] OR "marriage"[All Fields]) OR ("single parent"[MeSH Terms] OR ("single"[All Fields] AND "parent"[All Fields]) OR "single parent"[All Fields]) OR ("single person"[MeSH Terms] OR ("single"[All Fields] AND "person"[All Fields]) OR "single person"[All Fields]) OR ("widowhood"[MeSH Terms] OR "widowhood"[All Fields]) OR ("divorce"[MeSH Terms] OR "divorce"[All Fields] OR "divorced"[All Fields]) OR ("marriage"[MeSH Terms] OR "marriage"[All Fields] OR "married"[All Fields]) OR "never married"[All Fields] OR ("divorce"[MeSH Terms] OR "divorce"[All Fields] OR "separated"[All Fields]) OR ("divorce"[MeSH Terms] OR "divorce"[All Fields] OR "separation"[All Fields]) OR ("single person"[MeSH Terms] OR ("single"[All Fields] AND "person"[All Fields]) OR "single person"[All Fields] OR "single"[All Fields]) OR ("single person"[MeSH Terms] OR ("single"[All Fields] AND "person"[All Fields]) OR "single person"[All Fields] OR "unmarried"[All Fields]) OR ("widowhood"[MeSH Terms] OR "widowhood"[All Fields] OR "widow"[All Fields]) OR ("widowhood"[MeSH Terms] OR "widowhood"[All Fields] OR "widowed"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])		
20	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,478	05/28/2012
21	Combine	#19 and #20	617	05/28/2012

(Searched 1/1/2002 – 8/1/2012)

Key Question 3B: Job Function

PubMed, TRIS, Virginia Tech Transportation Institute

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
55	Job function PubMed	("employment"[MeSH Terms] OR "employment"[All Fields]) OR ("job application"[MeSH Terms] OR ("job"[All Fields] AND "application"[All Fields]) OR "job application"[All Fields]) OR ("job description"[MeSH Terms] OR ("job"[All Fields] AND "description"[All Fields]) OR "job description"[All Fields]) OR (job[All Fields] AND mobility[All Fields]) OR ("man-machine systems"[MeSH Terms] OR ("man-machine"[All Fields] AND "systems"[All Fields]) OR "man-machine systems"[All Fields] OR ("man"[All Fields] AND "machine"[All Fields] AND "systems"[All Fields]) OR "man machine systems"[All Fields]) OR ("task performance and analysis"[MeSH Terms] OR ("task"[All Fields] AND "performance"[All Fields] AND "analysis"[All Fields]) OR "task performance and analysis"[All Fields]) OR ("workload"[MeSH Terms] OR "workload"[All Fields]) OR (("workplace"[MeSH Terms] OR "workplace"[All Fields]) AND duties[All Fields]) OR duty[All Fields] OR "Job requirement"[All Fields] OR load[All Fields] OR loads[All Fields] OR responsibilities[All Fields] OR ("role"[MeSH Terms] OR "role"[All Fields]) OR ("role"[MeSH Terms] OR "role"[All Fields] OR "roles"[All Fields]) OR task[All Fields] OR tasks[All Fields] OR ("work"[MeSH Terms] OR "work"[All Fields]) OR	2,939,789	06/12/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
		"Work space"[All Fields] OR ("workplace"[MeSH Terms] OR "workplace"[All Fields] OR "worksite"[All Fields]) OR ("transportation"[MeSH Terms] OR "transportation"[All Fields] OR "commuted"[All Fields]) OR ("health services accessibility"[MeSH Terms] OR ("health"[All Fields] AND "services"[All Fields] AND "accessibility"[All Fields]) OR "health services accessibility"[All Fields] OR "distance"[All Fields]) OR ("health services accessibility"[MeSH Terms] OR ("health"[All Fields] AND "services"[All Fields] AND "accessibility"[All Fields]) OR "health services accessibility"[All Fields] OR "distances"[All Fields]) OR mile[All Fields] OR miles[All Fields] OR ("lifting"[MeSH Terms] OR "lifting"[All Fields] OR "lift"[All Fields]) OR lifts[All Fields] OR unload[All Fields] OR unloads[All Fields] OR paperwork[All Fields] OR ("research report"[MeSH Terms] OR ("research"[All Fields] AND "report"[All Fields]) OR "research report"[All Fields] OR "report"[All Fields]) OR ("research report"[MeSH Terms] OR ("research"[All Fields] AND "report"[All Fields]) OR "research report"[All Fields] OR "reports"[All Fields]) OR pre-trip[All Fields] OR post-trip[All Fields] OR inspection[All Fields] AND ("humans"[MeSH Terms] AND English[lang])		
56	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,530	06/12/2012
57	Combine	#55 and #56	10,136	06/12/2012
58	Limit by date	#57 and Publication date from 2002/01/01 to 2012/12/31	5,729	06/12/2012
78	Specific driver type TRID	“bus driv*” OR “CMV driv*” OR “coach driv*” OR “commercial driv*” OR “commercial motor vehicle driv*” OR “motor coach driv*” OR “professional driv*” OR shipper* OR “truck driv*” OR trucker* 2002-2012, English	4,822	06/17/2012
79	Eliminate duplicates		4,810 new records remain	06/17/2012

Searched 1/1/2002 – 8/1/2012

Key Question 3C: Work Environment

PubMed, TRIS, Virginia Tech Transportation Institute

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
59	Work environment	("employee grievances"[MeSH Terms] OR ("employee"[All Fields] AND "grievances"[All Fields]) OR "employee grievances"[All Fields]) OR ("human engineering"[MeSH Terms] OR ("human"[All Fields] AND "engineering"[All Fields]) OR "human	293,819	06/13/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
	PubMed	engineering"[All Fields]) OR ("job satisfaction"[MeSH Terms] OR ("job"[All Fields] AND "satisfaction"[All Fields]) OR "job satisfaction"[All Fields]) OR ("personnel downsizing"[MeSH Terms] OR ("personnel"[All Fields] AND "downsizing"[All Fields]) OR "personnel downsizing"[All Fields]) OR ("personnel staffing and scheduling"[MeSH Terms] OR ("personnel"[All Fields] AND "staffing"[All Fields] AND "scheduling"[All Fields]) OR "personnel staffing and scheduling"[All Fields]) OR ("personnel turnover"[MeSH Terms] OR ("personnel"[All Fields] AND "turnover"[All Fields]) OR "personnel turnover"[All Fields]) OR ("rest"[MeSH Terms] OR "rest"[All Fields]) OR ("salaries and fringe benefits"[MeSH Terms] OR ("salaries"[All Fields] AND "fringe"[All Fields] AND "benefits"[All Fields]) OR "salaries and fringe benefits"[All Fields]) OR ("sleep disorders, circadian rhythm"[MeSH Terms] OR ("sleep"[All Fields] AND "disorders"[All Fields] AND "circadian"[All Fields] AND "rhythm"[All Fields]) OR "circadian rhythm sleep disorders"[All Fields] OR ("shift"[All Fields] AND "work"[All Fields] AND "sleep"[All Fields] AND "disorder"[All Fields]) OR "shift work sleep disorder"[All Fields]) OR ("sleep disorders, circadian rhythm"[MeSH Terms] OR ("sleep"[All Fields] AND "disorders"[All Fields] AND "circadian"[All Fields] AND "rhythm"[All Fields]) OR "circadian rhythm sleep disorders"[All Fields] OR ("sleep"[All Fields] AND "disorder"[All Fields] AND "shift"[All Fields] AND "work"[All Fields])) OR ("sleep disorders, circadian rhythm"[MeSH Terms] OR ("sleep"[All Fields] AND "disorders"[All Fields] AND "circadian"[All Fields] AND "rhythm"[All Fields]) OR "circadian rhythm sleep disorders"[All Fields] OR ("sleep"[All Fields] AND "disorders"[All Fields] AND "circadian"[All Fields] AND "rhythm"[All Fields]) OR "sleep disorders, circadian rhythm"[All Fields]) OR ("staff development"[MeSH Terms] OR ("staff"[All Fields] AND "development"[All Fields]) OR "staff development"[All Fields]) OR Break[All Fields] OR Ergonomic[All Fields] OR ("human engineering"[MeSH Terms] OR ("human"[All Fields] AND "engineering"[All Fields]) OR "human engineering"[All Fields] OR "ergonomics"[All Fields]) OR "Job burnout"[All Fields] OR "Job demand"[All Fields] OR "Job performance"[All Fields] OR "Job strain"[All Fields] OR "Job stress"[All Fields] OR "Night shift"[All Fields] OR "Occupational hazards"[All Fields] OR "Occupational injury"[All Fields] OR "Occupational noise"[All Fields] OR Passenger[All Fields] OR passengers[All Fields] OR ("appointments and schedules"[MeSH Terms] OR ("appointments"[All Fields] AND "schedules"[All Fields]) OR "appointments and schedules"[All Fields] OR "schedule"[All Fields]) OR Shift[All Fields] OR "Shift work"[All Fields] OR Staff[All Fields] OR "Work satisfaction"[All Fields] OR diesel[All Fields] OR ("toxins, biological"[MeSH Terms] OR ("toxins"[All Fields] AND "biological"[All Fields]) OR "biological toxins"[All Fields] OR "toxin"[All Fields]) OR toxic[All Fields] AND (("2002/01/01"[PDAT] : "2012/12/31"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])		
60	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,535	06/13/2012
61	Combine	#59 and #60	1,461	06/13/2012

Searched 1/1/2002 – 8/1/2012

3d. Health Behaviors: PubMed, TRIS, Virginia Tech Transportation Institute

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
22	Obesity PubMed	("adiposity"[MeSH Terms] OR "adiposity"[All Fields]) OR ("adipose tissue"[MeSH Terms] OR ("adipose"[All Fields] AND "tissue"[All Fields]) OR "adipose tissue"[All Fields]) OR ("appetite depressants"[MeSH Terms] OR ("appetite"[All Fields] AND "depressants"[All Fields]) OR "appetite depressants"[All Fields] OR "appetite depressants"[Pharmacological Action]) OR ("bariatrics"[MeSH Terms] OR "bariatrics"[All Fields]) OR ("body fat distribution"[MeSH Terms] OR ("body"[All Fields] AND "fat"[All Fields] AND "distribution"[All Fields]) OR "body fat distribution"[All Fields]) OR ("body mass index"[MeSH Terms] OR ("body"[All Fields] AND "mass"[All Fields] AND "index"[All Fields]) OR "body mass index"[All Fields]) OR ("body size"[MeSH Terms] OR ("body"[All Fields] AND "size"[All Fields]) OR "body size"[All Fields]) OR ("body weight"[MeSH Terms] OR ("body"[All Fields] AND "weight"[All Fields]) OR "body weight"[All Fields]) OR ("diet, reducing"[MeSH Terms] OR ("diet"[All Fields] AND "reducing"[All Fields]) OR "reducing diet"[All Fields] OR ("diet"[All Fields] AND "reducing"[All Fields]) OR "diet, reducing"[All Fields]) OR ("obesity, morbid"[MeSH Terms] OR ("obesity"[All Fields] AND "morbid"[All Fields]) OR "morbid obesity"[All Fields] OR ("morbid"[All Fields] AND "obesity"[All Fields])) OR ("obesity"[MeSH Terms] OR "obesity"[All Fields]) OR ("obesity, abdominal"[MeSH Terms] OR ("obesity"[All Fields] AND "abdominal"[All Fields]) OR "abdominal obesity"[All Fields] OR ("obesity"[All Fields] AND "abdominal"[All Fields]) OR "obesity, abdominal"[All Fields]) OR ("obesity, morbid"[MeSH Terms] OR ("obesity"[All Fields] AND "morbid"[All Fields]) OR "morbid obesity"[All Fields] OR ("obesity"[All Fields] AND "morbid"[All Fields]) OR "obesity, morbid"[All Fields]) OR ("overweight"[MeSH Terms] OR "overweight"[All Fields]) OR ("skinfold thickness"[MeSH Terms] OR ("skinfold"[All Fields] AND "thickness"[All Fields]) OR "skinfold thickness"[All Fields]) OR ("waist circumference"[MeSH Terms] OR ("waist"[All Fields] AND "circumference"[All Fields]) OR "waist circumference"[All Fields]) OR ("waist-hip ratio"[MeSH Terms] OR ("waist-hip"[All Fields] AND "ratio"[All Fields]) OR "waist-hip ratio"[All Fields] OR ("waist"[All Fields] AND "hip"[All Fields] AND "ratio"[All Fields]) OR "waist hip ratio"[All Fields]) OR "belly fat"[All Fields] OR BMI[All Fields] OR "body weight"[All Fields] OR "fat"[All Fields] OR ("weights and measures"[MeSH Terms] OR ("weights"[All Fields] AND "measures"[All Fields]) OR "weights and measures"[All Fields] OR "weight"[All Fields] OR "body weight"[MeSH Terms] OR ("body"[All Fields] AND "weight"[All Fields]) OR "body weight"[All Fields]) OR "weight loss"[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	645,300	05/28/2012
23	Combine	#20 and #22	566	05/28/2012
24	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,514	06/02/2012
25	Tobacco use PubMed	("nicotine"[MeSH Terms] OR "nicotine"[All Fields]) OR ("smoking"[MeSH Terms] OR "smoking"[All Fields]) OR ("tobacco"[MeSH Terms] OR "tobacco"[All Fields]) OR ("tobacco, smokeless"[MeSH Terms] OR ("tobacco"[All Fields] AND "smokeless"[All Fields]) OR "smokeless tobacco"[All Fields] OR ("tobacco"[All Fields] AND "smokeless"[All Fields]) OR "tobacco, smokeless"[All Fields]) OR ("tobacco smoke pollution"[MeSH Terms] OR ("tobacco"[All Fields] AND "smoke"[All Fields] AND "pollution"[All Fields]) OR	162,747	06/02/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
		"tobacco smoke pollution"[All Fields]) OR ("tobacco use cessation"[MeSH Terms] OR ("tobacco"[All Fields] AND "cessation"[All Fields]) OR "tobacco use cessation"[All Fields]) OR ("tobacco use disorder"[MeSH Terms] OR ("tobacco"[All Fields] AND "disorder"[All Fields]) OR "tobacco use disorder"[All Fields]) OR ("smoking cessation"[MeSH Terms] OR ("smoking"[All Fields] AND "cessation"[All Fields]) OR "smoking cessation"[All Fields]) OR "chewing tobacco"[All Fields] OR "cigarette smoke"[All Fields] OR "cigarette smokers"[All Fields] OR "former smokers"[All Fields] OR "heavy smoker"[All Fields] OR "light smoker"[All Fields] OR "nonsmoker"[All Fields] OR "never smoker"[All Fields] OR "oral tobacco"[All Fields] OR "passive smoker"[All Fields] OR "passive smoking"[All Fields] OR "secondhand smoke"[All Fields] OR smokers[All Fields] OR ("tobacco, smokeless"[MeSH Terms] OR ("tobacco"[All Fields] AND "smokeless"[All Fields]) OR "smokeless tobacco"[All Fields] OR "snuff"[All Fields]) OR "tobacco smoke"[All Fields] OR "tobacco smoking"[All Fields] AND ("humans"[MeSH Terms] AND English[lang])		
26	Combine	#24 and #25	432	06/02/2012
27	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,525	06/06/2012
28	Exercise PubMed	("exercise"[MeSH Terms] OR "exercise"[All Fields]) OR ("movement"[MeSH Terms] OR "movement"[All Fields]) OR ("motor activity"[MeSH Terms] OR ("motor"[All Fields] AND "activity"[All Fields]) OR "motor activity"[All Fields]) OR ("physical exertion"[MeSH Terms] OR ("physical"[All Fields] AND "exertion"[All Fields]) OR "physical exertion"[All Fields]) OR ("physical fitness"[MeSH Terms] OR ("physical"[All Fields] AND "fitness"[All Fields]) OR "physical fitness"[All Fields]) OR ("sports"[MeSH Terms] OR "sports"[All Fields]) OR ("walking"[MeSH Terms] OR "walking"[All Fields]) OR aerobic[All Fields] OR "lifting weights"[All Fields] OR "lift weights"[All Fields] OR "physical activity"[All Fields] OR "weight lifting"[All Fields] OR weightlifting[All Fields] OR workout[All Fields] OR ("sports"[MeSH Terms] OR "sports"[All Fields] OR "sport"[All Fields]) OR gym[All Fields] OR ("callisthenics"[All Fields] OR "gymnastics"[MeSH Terms] OR "gymnastics"[All Fields] OR "calisthenics"[All Fields]) OR "work out"[All Fields] OR fitness[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	446,360	06/06/2012
29	Combine	#27 and #28	1,166	06/06/2012
30	Drinking PubMed	("alcohol drinking"[MeSH Terms] OR ("alcohol"[All Fields] AND "drinking"[All Fields]) OR "alcohol drinking"[All Fields]) OR ("alcoholic beverages"[MeSH Terms] OR ("alcoholic"[All Fields] AND "beverages"[All Fields]) OR "alcoholic beverages"[All Fields]) OR ("alcoholic intoxication"[MeSH Terms] OR ("alcoholic"[All Fields] AND "intoxication"[All Fields]) OR "alcoholic intoxication"[All Fields]) OR ("alcoholism"[MeSH Terms] OR "alcoholism"[All Fields]) OR ("ethanol"[MeSH Terms] OR "ethanol"[All Fields] OR "alcohol"[All Fields] OR "alcohols"[MeSH Terms] OR "alcohols"[All Fields]) OR "alcohol consumption"[All Fields] AND (lcohol[All Fields] AND ("dependency (psychology)"[MeSH Terms] OR ("dependency"[All Fields] AND "(psychology)"[All Fields]) OR "dependency (psychology)"[All Fields] OR "dependence"[All Fields])) OR ("alcoholics"[MeSH Terms] OR "alcoholics"[All Fields] OR "alcoholic"[All Fields]) OR "binge drinking"[All Fields] OR drink[All Fields] OR drinks[All Fields] OR ("drinking"[MeSH Terms] OR	94,940	06/07/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
		"drinking"[All Fields] OR "alcohol drinking"[MeSH Terms] OR ("alcohol"[All Fields] AND "drinking"[All Fields]) OR "alcohol drinking"[All Fields]) OR drinker[All Fields] OR drinkers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])		
31	Specific driver type PubMed	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields]) OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	11,525	06/07/2012
32	Combine	#30 and #31	380	06/07/2012
33	Diet PubMed	("diet"[MeSH Terms] OR "diet"[All Fields]) OR ("diet surveys"[MeSH Terms] OR ("diet"[All Fields] AND "surveys"[All Fields]) OR "diet surveys"[All Fields]) OR ("eating"[MeSH Terms] OR "eating"[All Fields]) OR ("eating behaviour"[All Fields] OR "feeding behavior"[MeSH Terms] OR ("feeding"[All Fields] AND "behavior"[All Fields]) OR "feeding behavior"[All Fields] OR ("eating"[All Fields] AND "behavior"[All Fields]) OR "eating behavior"[All Fields]) OR ("feeding behaviour"[All Fields] OR "feeding behavior"[MeSH Terms] OR ("feeding"[All Fields] AND "behavior"[All Fields]) OR "feeding behavior"[All Fields]) OR ("food"[MeSH Terms] OR "food"[All Fields]) OR ("nutrition assessment"[MeSH Terms] OR ("nutrition"[All Fields] AND "assessment"[All Fields]) OR "nutrition assessment"[All Fields]) OR ("nutrition surveys"[MeSH Terms] OR ("nutrition"[All Fields] AND "surveys"[All Fields]) OR "nutrition surveys"[All Fields]) OR ("nutritional status"[MeSH Terms] OR ("nutritional"[All Fields] AND "status"[All Fields]) OR "nutritional status"[All Fields]) OR DASH[All Fields] OR ("diet"[MeSH Terms] OR "diet"[All Fields] OR "dietary"[All Fields]) OR "fat"[All Fields] OR ("fruit"[MeSH Terms] OR "fruit"[All Fields]) OR ("eating"[MeSH Terms] OR "eating"[All Fields] OR "ingestion"[All Fields]) OR ("eating"[MeSH Terms] OR "eating"[All Fields] OR "ingest"[All Fields]) OR "National Health and Nutrition Examination Survey"[All Fields] OR ("nutrition surveys"[MeSH Terms] OR ("nutrition"[All Fields] AND "surveys"[All Fields]) OR "nutrition surveys"[All Fields] OR "nhanes"[All Fields]) OR ("nutritional status"[MeSH Terms] OR ("nutritional"[All Fields] AND "status"[All Fields]) OR "nutritional status"[All Fields] OR "nutrition"[All Fields] OR "nutritional sciences"[MeSH Terms] OR ("nutritional"[All Fields] AND "sciences"[All Fields]) OR "nutritional sciences"[All Fields]) OR eat[All Fields] OR eats[All Fields] OR nutritional[All Fields] OR ("vegetables"[MeSH Terms] OR "vegetables"[All Fields] OR "vegetable"[All Fields]) OR ("vegetables"[MeSH Terms] OR "vegetables"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	569,785	06/07/2012
34	Combine	#31 and #33	327	06/07/2012
35	Cardiovascular diseases PubMed	("cardiovascular abnormalities"[MeSH Terms] OR ("cardiovascular"[All Fields] AND "abnormalities"[All Fields]) OR "cardiovascular abnormalities"[All Fields]) OR ("cardiovascular infections"[MeSH Terms] OR ("cardiovascular"[All Fields] AND "infections"[All Fields]) OR "cardiovascular infections"[All Fields]) OR ("coronary disease"[MeSH Terms] OR ("coronary"[All Fields] AND "disease"[All Fields]) OR "coronary disease"[All Fields]) OR ("heart diseases"[MeSH Terms] OR ("heart"[All Fields] AND "diseases"[All Fields]) OR "heart diseases"[All Fields]) OR ("heart valve diseases"[MeSH Terms] OR ("heart"[All Fields] AND "valve"[All Fields] AND "diseases"[All Fields]) OR "heart valve diseases"[All Fields]) OR ("hypertension"[MeSH Terms] OR "hypertension"[All Fields]) OR ("myocardial ischaemia"[All Fields] OR "myocardial ischemia"[MeSH Terms] OR ("myocardial"[All Fields] AND "ischemia"[All Fields]) OR "myocardial ischemia"[All Fields] OR "coronary artery disease"[MeSH Terms] OR	1,142,502	06/07/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
		("coronary"[All Fields] AND "artery"[All Fields] AND "disease"[All Fields]) OR "coronary artery disease"[All Fields] OR ("myocardial"[All Fields] AND "ischemia"[All Fields]) OR "myocardial ischemia"[All Fields] OR "Myocardial Ischemia"[MeSH Terms] OR ("Myocardial"[All Fields] AND "Ischemia"[All Fields]) OR "Myocardial Ischemia"[All Fields] OR ("myocardial"[All Fields] AND "ischemia"[All Fields])) OR ("pulmonary heart disease"[MeSH Terms] OR ("pulmonary"[All Fields] AND "heart"[All Fields] AND "disease"[All Fields]) OR "pulmonary heart disease"[All Fields]) OR ("vascular diseases"[MeSH Terms] OR ("vascular"[All Fields] AND "diseases"[All Fields]) OR "vascular diseases"[All Fields]) OR "congenital heart defect"[All Fields] OR "cardiac diseases"[All Fields] AND ("humans"[MeSH Terms] AND English[lang])		
36	Combine	#31 and #35	1,077	06/07/2012
37	Cancer PubMed	("neoplasms"[MeSH Terms] OR "neoplasms"[All Fields]) OR ("neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "cancer"[All Fields]) OR ("neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "cancer"[All Fields]) OR ("neoplasms"[MeSH Terms] OR "neoplasms"[All Fields]) OR ("tumour"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "tumor"[All Fields]) OR ("tumours"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "tumors"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	1,841,001	06/07/2012
38	Combine	#31 and #38	514	06/07/2012
39	Cerebrovascular disease PubMed	("brain ischaemia"[All Fields] OR "brain ischemia"[MeSH Terms] OR ("brain"[All Fields] AND "ischemia"[All Fields]) OR "brain ischemia"[All Fields]) OR ("carotid artery diseases"[MeSH Terms] OR ("carotid"[All Fields] AND "artery"[All Fields] AND "diseases"[All Fields]) OR "carotid artery diseases"[All Fields]) OR ("stroke"[MeSH Terms] OR "stroke"[All Fields]) OR cerebrovascular[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	195,042	06/07/2012
40	Combine	#31 and #39	150	06/07/2012
41	Respiratory disease PubMed	("asthma"[MeSH Terms] OR "asthma"[All Fields]) OR ("asthma, occupational"[MeSH Terms] OR ("asthma"[All Fields] AND "occupational"[All Fields]) OR "occupational asthma"[All Fields] OR ("asthma"[All Fields] AND "occupational"[All Fields]) OR "asthma, occupational"[All Fields]) OR ("bronchial diseases"[MeSH Terms] OR ("bronchial"[All Fields] AND "diseases"[All Fields]) OR "bronchial diseases"[All Fields]) OR ("bronchitis"[MeSH Terms] OR "bronchitis"[All Fields]) OR ("lung diseases, obstructive"[MeSH Terms] OR ("lung"[All Fields] AND "diseases"[All Fields] AND "obstructive"[All Fields]) OR "obstructive lung diseases"[All Fields] OR ("lung"[All Fields] AND "diseases"[All Fields] AND "obstructive"[All Fields]) OR "lung diseases, obstructive"[All Fields]) OR ("respiratory tract diseases"[MeSH Terms] OR ("respiratory"[All Fields] AND "tract"[All Fields] AND "diseases"[All Fields]) OR "respiratory tract diseases"[All Fields]) OR ("respiratory tract neoplasms"[MeSH Terms] OR ("respiratory"[All Fields] AND "tract"[All Fields] AND "neoplasms"[All Fields]) OR "respiratory tract neoplasms"[All Fields]) OR ("sleep apnea, obstructive"[MeSH Terms] OR ("sleep"[All Fields] AND "apnea"[All Fields] AND "obstructive"[All Fields]) OR "obstructive sleep apnea"[All Fields] OR ("sleep"[All Fields] AND "apnea"[All Fields] AND "obstructive"[All Fields]) OR "sleep apnea, obstructive"[All Fields]) OR ("sleep apnoea syndromes"[All Fields] OR "sleep apnea syndromes"[MeSH Terms] OR ("sleep"[All Fields] AND "apnea"[All Fields] AND "syndromes"[All Fields]) OR "sleep apnea syndromes"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	602,024	06/07/2012
42	Combine	#31 and #41	625	06/07/2012
43	Specific driver type	bus[All Fields] OR ("motor vehicles"[MeSH Terms] OR ("motor"[All Fields] AND "vehicles"[All Fields]) OR "motor vehicles"[All Fields] OR "buses"[All Fields]) OR "bus driver"[All Fields] OR "bus drivers"[All Fields] OR (CMV[All Fields] AND driver[All Fields])	11,529	06/09/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
	PubMed	OR "CMV drivers"[All Fields] OR (coach[All Fields] AND driver[All Fields]) OR "coach drivers"[All Fields] OR (commercial[All Fields] AND driver[All Fields]) OR "commercial drivers"[All Fields] OR "commercial motor vehicle driver"[All Fields] OR "commercial motor vehicle drivers"[All Fields] OR (motor[All Fields] AND coach[All Fields] AND driver[All Fields]) OR (motor[All Fields] AND coach[All Fields] AND drivers[All Fields]) OR "professional driver"[All Fields] OR "professional drivers"[All Fields] OR shipper[All Fields] OR shippers[All Fields] OR "truck driver"[All Fields] OR "truck drivers"[All Fields] OR trucker[All Fields] OR truckers[All Fields] AND ("humans"[MeSH Terms] AND English[lang])		
44	Endocrine disease PubMed	("diabetes mellitus"[MeSH Terms] OR ("diabetes"[All Fields] AND "mellitus"[All Fields]) OR "diabetes mellitus"[All Fields]) OR ("endocrine system diseases"[MeSH Terms] OR ("endocrine"[All Fields] AND "system"[All Fields] AND "diseases"[All Fields]) OR "endocrine system diseases"[All Fields]) OR ("thyroid diseases"[MeSH Terms] OR ("thyroid"[All Fields] AND "diseases"[All Fields]) OR "thyroid diseases"[All Fields]) OR ("diabetes mellitus"[MeSH Terms] OR ("diabetes"[All Fields] AND "mellitus"[All Fields]) OR "diabetes mellitus"[All Fields] OR "diabetes"[All Fields] OR "diabetes insipidus"[MeSH Terms] OR ("diabetes"[All Fields] AND "insipidus"[All Fields]) OR "diabetes insipidus"[All Fields]) OR Diabetic[All Fields] OR "Insulin resistance"[All Fields] OR ("insulin"[MeSH Terms] OR "insulin"[All Fields]) OR ("glucose"[MeSH Terms] OR "glucose"[All Fields]) OR Hyperthyroid[All Fields] OR ("hypothyroidism"[MeSH Terms] OR "hypothyroidism"[All Fields] OR "hypothyroid"[All Fields]) OR ("hyperthyroidism"[MeSH Terms] OR "hyperthyroidism"[All Fields]) OR ("hypothyroidism"[MeSH Terms] OR "hypothyroidism"[All Fields]) OR ("acromegaly"[MeSH Terms] OR "acromegaly"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	653,794	06/09/2012
45	Combine	#43 and #44	164	06/09/2012
46	Renal disease PubMed	("kidney diseases"[MeSH Terms] OR ("kidney"[All Fields] AND "diseases"[All Fields]) OR "kidney diseases"[All Fields]) OR ("kidney failure, chronic"[MeSH Terms] OR ("kidney"[All Fields] AND "failure"[All Fields] AND "chronic"[All Fields]) OR "chronic kidney failure"[All Fields] OR ("kidney"[All Fields] AND "failure"[All Fields] AND "chronic"[All Fields]) OR "kidney failure, chronic"[All Fields]) OR "renal disease"[All Fields] OR renal[All Fields] OR ("kidney"[MeSH Terms] OR "kidney"[All Fields]) OR "chronic kidney disease"[All Fields] AND ("humans"[MeSH Terms] AND English[lang])	446,432	06/09/2012
47	Combine	#43 and #46	85	06/09/2012
48	Neurological disorders PubMed	("nervous system diseases"[MeSH Terms] OR ("nervous"[All Fields] AND "system"[All Fields] AND "diseases"[All Fields]) OR "nervous system diseases"[All Fields]) OR ("nervous system neoplasms"[MeSH Terms] OR ("nervous"[All Fields] AND "system"[All Fields] AND "neoplasms"[All Fields]) OR "nervous system neoplasms"[All Fields]) OR ("neurodegenerative diseases"[MeSH Terms] OR ("neurodegenerative"[All Fields] AND "diseases"[All Fields]) OR "neurodegenerative diseases"[All Fields]) OR ("neuromuscular diseases"[MeSH Terms] OR ("neuromuscular"[All Fields] AND "diseases"[All Fields]) OR "neuromuscular diseases"[All Fields]) OR ("paralysis"[MeSH Terms] OR "paralysis"[All Fields]) OR ("seizures"[MeSH Terms] OR "seizures"[All Fields]) OR ("trauma, nervous system"[MeSH Terms] OR ("trauma"[All Fields] AND "nervous"[All Fields] AND "system"[All Fields]) OR "nervous system trauma"[All Fields] OR ("trauma"[All Fields] AND "nervous"[All Fields] AND "system"[All Fields]) OR "trauma, nervous system"[All Fields]) OR ("parkinson disease"[MeSH Terms] OR ("parkinson"[All Fields] AND "disease"[All Fields]) OR "parkinson disease"[All Fields] OR "parkinson's"[All Fields]) OR ("alzheimer disease"[MeSH Terms] OR ("alzheimer"[All Fields] AND "disease"[All Fields]) OR "alzheimer disease"[All Fields] OR "alzheimer's"[All Fields]) OR Huntington's[All Fields] OR ("epilepsy"[MeSH Terms] OR "epilepsy"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	1,273,594	06/09/2012
49	Combine	#43 and #48	1,333	06/09/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
50	Musculoskeletal disease PubMed	("bone diseases"[MeSH Terms] OR ("bone"[All Fields] AND "diseases"[All Fields]) OR "bone diseases"[All Fields]) OR ("cartilage diseases"[MeSH Terms] OR ("cartilage"[All Fields] AND "diseases"[All Fields]) OR "cartilage diseases"[All Fields]) OR ("foot diseases"[MeSH Terms] OR ("foot"[All Fields] AND "diseases"[All Fields]) OR "foot diseases"[All Fields]) OR ("hand deformities"[MeSH Terms] OR ("hand"[All Fields] AND "deformities"[All Fields]) OR "hand deformities"[All Fields]) OR ("joint diseases"[MeSH Terms] OR ("joint"[All Fields] AND "diseases"[All Fields]) OR "joint diseases"[All Fields]) OR ("muscular diseases"[MeSH Terms] OR ("muscular"[All Fields] AND "diseases"[All Fields]) OR "muscular diseases"[All Fields]) OR (Musculoskeletal[All Fields] AND ("abnormalities"[Subheading] OR "abnormalities"[All Fields] OR "deformities"[All Fields] OR "congenital abnormalities"[MeSH Terms] OR ("congenital"[All Fields] AND "abnormalities"[All Fields]) OR "congenital abnormalities"[All Fields])) OR ("musculoskeletal diseases"[MeSH Terms] OR ("musculoskeletal"[All Fields] AND "diseases"[All Fields]) OR "musculoskeletal diseases"[All Fields]) OR ("rheumatic diseases"[MeSH Terms] OR ("rheumatic"[All Fields] AND "diseases"[All Fields]) OR "rheumatic diseases"[All Fields]) OR ("back pain"[MeSH Terms] OR ("back"[All Fields] AND "pain"[All Fields]) OR "back pain"[All Fields]) OR ("low back pain"[MeSH Terms] OR ("low"[All Fields] AND "back"[All Fields] AND "pain"[All Fields]) OR "low back pain"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	555,490	06/09/2012
51	Combine	#43 and #50	330	06/09/2012
52	Psychological disorders PubMed	("alcohol-related disorders"[MeSH Terms] OR ("alcohol-related"[All Fields] AND "disorders"[All Fields]) OR "alcohol-related disorders"[All Fields] OR ("alcohol"[All Fields] AND "related"[All Fields] AND "disorders"[All Fields]) OR "alcohol related disorders"[All Fields]) OR ("anxiety disorders"[MeSH Terms] OR ("anxiety"[All Fields] AND "disorders"[All Fields]) OR "anxiety disorders"[All Fields]) OR ("eating disorders"[MeSH Terms] OR ("eating"[All Fields] AND "disorders"[All Fields]) OR "eating disorders"[All Fields]) OR ("mental disorders"[MeSH Terms] OR ("mental"[All Fields] AND "disorders"[All Fields]) OR "mental disorders"[All Fields]) OR ("mood disorders"[MeSH Terms] OR ("mood"[All Fields] AND "disorders"[All Fields]) OR "mood disorders"[All Fields]) OR ("neurotic disorders"[MeSH Terms] OR ("neurotic"[All Fields] AND "disorders"[All Fields]) OR "neurotic disorders"[All Fields]) OR ("obsessive-compulsive disorder"[MeSH Terms] OR ("obsessive-compulsive"[All Fields] AND "disorder"[All Fields]) OR "obsessive-compulsive disorder"[All Fields] OR ("obsessive"[All Fields] AND "compulsive"[All Fields] AND "disorder"[All Fields]) OR "obsessive compulsive disorder"[All Fields]) OR ("personality disorders"[MeSH Terms] OR ("personality"[All Fields] AND "disorders"[All Fields]) OR "personality disorders"[All Fields]) OR ("schizophrenia and disorders with psychotic features"[MeSH Terms] OR ("schizophrenia"[All Fields] AND "disorders"[All Fields] AND "psychotic"[All Fields] AND "features"[All Fields])) OR ("substance-related disorders"[MeSH Terms] OR ("substance-related"[All Fields] AND "disorders"[All Fields]) OR "substance-related disorders"[All Fields] OR ("substance"[All Fields] AND "related"[All Fields] AND "disorders"[All Fields]) OR "substance related disorders"[All Fields]) OR ("alcoholism"[MeSH Terms] OR "alcoholism"[All Fields]) OR ("behavior, addictive"[MeSH Terms] OR ("behavior"[All Fields] AND "addictive"[All Fields]) OR "addictive behavior"[All Fields] OR "addiction"[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])	759,821	06/09/2012
53	Combine	#43 & #52	789	06/09/2012
54	Commercial driver & disease TRID	“commercial driver” AND disease	24	06/09/2012
62	General	("health behaviour"[All Fields] OR "health behavior"[MeSH Terms] OR ("health"[All Fields] AND "behavior"[All Fields]) OR "health	1,998,798	06/13/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
	health PubMed	behavior"[All Fields]) OR ("life style"[MeSH Terms] OR ("life"[All Fields] AND "style"[All Fields]) OR "life style"[All Fields]) OR ("risk reduction behaviour"[All Fields] OR "risk reduction behavior"[MeSH Terms] OR ("risk"[All Fields] AND "reduction"[All Fields] AND "behavior"[All Fields]) OR "risk reduction behavior"[All Fields]) OR ("sedentary lifestyle"[MeSH Terms] OR ("sedentary"[All Fields] AND "lifestyle"[All Fields]) OR "sedentary lifestyle"[All Fields]) OR ("activities of daily living"[MeSH Terms] OR ("activities"[All Fields] AND "daily"[All Fields] AND "living"[All Fields]) OR "activities of daily living"[All Fields]) OR ("attitude to health"[MeSH Terms] OR ("attitude"[All Fields] AND "health"[All Fields]) OR "attitude to health"[All Fields]) OR ("sickness impact profile"[MeSH Terms] OR ("sickness"[All Fields] AND "impact"[All Fields] AND "profile"[All Fields]) OR "sickness impact profile"[All Fields]) OR ("disease"[MeSH Terms] OR "disease"[All Fields]) OR ("health"[MeSH Terms] OR "health"[All Fields]) OR ("health status"[MeSH Terms] OR ("health"[All Fields] AND "status"[All Fields]) OR "health status"[All Fields]) OR ("health status indicators"[MeSH Terms] OR ("health"[All Fields] AND "status"[All Fields] AND "indicators"[All Fields]) OR "health status indicators"[All Fields]) OR ("health status disparities"[MeSH Terms] OR ("health"[All Fields] AND "status"[All Fields] AND "disparities"[All Fields]) OR "health status disparities"[All Fields]) OR ("life expectancy"[MeSH Terms] OR ("life"[All Fields] AND "expectancy"[All Fields]) OR "life expectancy"[All Fields]) OR ("life tables"[MeSH Terms] OR ("life"[All Fields] AND "tables"[All Fields]) OR "life tables"[All Fields]) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "morbidity"[All Fields] OR "morbidity"[MeSH Terms]) OR ("mortality"[Subheading] OR "mortality"[All Fields] OR "mortality"[MeSH Terms]) OR ("occupational health"[MeSH Terms] OR ("occupational"[All Fields] AND "health"[All Fields]) OR "occupational health"[All Fields]) OR "Health risk appraisal"[All Fields] OR "Health status index"[All Fields] OR "Health status indexes"[All Fields] OR "Self care"[All Fields] OR Ill[All Fields] OR Illness[All Fields] OR Sick[All Fields] AND (("2002/01/01"[PDAT] : "2012/12/31"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])		
63	Combine	#60 and #62	4,150	06/13/2012
64	Hearing PubMed	("hearing"[MeSH Terms] OR "hearing"[All Fields]) OR ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) OR ("deafness"[MeSH Terms] OR "deafness"[All Fields]) OR ("hearing impaired persons"[MeSH Terms] OR ("hearing"[All Fields] AND "impaired"[All Fields] AND "persons"[All Fields]) OR "hearing impaired persons"[All Fields]) OR ("hearing disorders"[MeSH Terms] OR ("hearing"[All Fields] AND "disorders"[All Fields]) OR "hearing disorders"[All Fields]) OR ("auditory threshold"[MeSH Terms] OR ("auditory"[All Fields] AND "threshold"[All Fields]) OR "auditory threshold"[All Fields]) OR ("hearing disorders"[MeSH Terms] OR ("hearing"[All Fields] AND "disorders"[All Fields]) OR "hearing disorders"[All Fields]) OR ("auditory threshold"[MeSH Terms] OR ("auditory"[All Fields] AND "threshold"[All Fields]) OR "auditory threshold"[All Fields]) OR ("auditory perception"[MeSH Terms] OR ("auditory"[All Fields] AND "perception"[All Fields]) OR "auditory perception"[All Fields]) OR ("auditory diseases, central"[MeSH Terms] OR ("auditory"[All Fields] AND "diseases"[All Fields] AND "central"[All Fields]) OR "central auditory diseases"[All Fields] OR ("auditory"[All Fields] AND "diseases"[All Fields] AND "central"[All Fields]) OR "auditory diseases, central"[All Fields]) OR ("auditory perceptual disorders"[MeSH Terms] OR ("auditory"[All Fields] AND "perceptual"[All Fields] AND "disorders"[All Fields]) OR "auditory perceptual disorders"[All Fields]) OR ("hearing impaired persons"[MeSH Terms] OR ("hearing"[All Fields] AND "impaired"[All Fields] AND "persons"[All Fields]) OR "hearing impaired persons"[All Fields] OR "deaf"[All Fields]) OR "Hard of hearing"[All Fields] OR auditory[All Fields] AND (("2002/01/01"[PDAT] : "2012/12/31"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])	47,884	06/13/2012
65	Combine	#60 and #64	117	06/13/2012
66	Vision	("blindness"[MeSH Terms] OR "blindness"[All Fields]) OR ("visually impaired persons"[MeSH Terms] OR ("visually"[All Fields] AND "impaired"[All Fields] AND "persons"[All Fields]) OR "visually impaired persons"[All Fields]) OR ("vision, low"[MeSH Terms] OR	261,203	06/13/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
	PubMed	("vision"[All Fields] AND "low"[All Fields]) OR "low vision"[All Fields] OR ("vision"[All Fields] AND "low"[All Fields]) OR "vision, low"[All Fields]) OR ("vision, ocular"[MeSH Terms] OR ("vision"[All Fields] AND "ocular"[All Fields]) OR "ocular vision"[All Fields] OR ("vision"[All Fields] AND "ocular"[All Fields]) OR "vision, ocular"[All Fields]) OR ("colour vision"[All Fields] OR "color vision"[MeSH Terms] OR ("color"[All Fields] AND "vision"[All Fields]) OR "color vision"[All Fields]) OR ("night vision"[MeSH Terms] OR ("night"[All Fields] AND "vision"[All Fields]) OR "night vision"[All Fields]) OR ("visual perception"[MeSH Terms] OR ("visual"[All Fields] AND "perception"[All Fields]) OR "visual perception"[All Fields]) OR ("eye diseases"[MeSH Terms] OR ("eye"[All Fields] AND "diseases"[All Fields]) OR "eye diseases"[All Fields]) OR ("vision disorders"[MeSH Terms] OR ("vision"[All Fields] AND "disorders"[All Fields]) OR "vision disorders"[All Fields]) OR ("optic nerve diseases"[MeSH Terms] OR ("optic"[All Fields] AND "nerve"[All Fields] AND "diseases"[All Fields]) OR "optic nerve diseases"[All Fields]) OR ("visually impaired persons"[MeSH Terms] OR ("visually"[All Fields] AND "impaired"[All Fields] AND "persons"[All Fields]) OR "visually impaired persons"[All Fields] OR "blind"[All Fields] OR "blindness"[MeSH Terms] OR "blindness"[All Fields]) OR Sightless[All Fields] OR ("vision, ocular"[MeSH Terms] OR ("vision"[All Fields] AND "ocular"[All Fields]) OR "ocular vision"[All Fields] OR "sight"[All Fields]) OR Eyesight[All Fields] OR ("vision, ocular"[MeSH Terms] OR ("vision"[All Fields] AND "ocular"[All Fields]) OR "ocular vision"[All Fields] OR "vision"[All Fields]) OR Visual[All Fields] OR "sight loss"[All Fields] AND (("2002/01/01"[PDAT] : "2012/12/31"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])		
67	Combine	#60 and #66	320	06/13/2012
68	Epidemiology PubMed	("behavioural risk factor surveillance system"[All Fields] OR "behavioral risk factor surveillance system"[MeSH Terms] OR ("behavioral"[All Fields] AND "risk"[All Fields] AND "factor"[All Fields] AND "surveillance"[All Fields] AND "system"[All Fields]) OR "behavioral risk factor surveillance system"[All Fields]) OR ("cause of death"[MeSH Terms] OR ("cause"[All Fields] AND "death"[All Fields]) OR "cause of death"[All Fields] OR ("causes"[All Fields] AND "death"[All Fields]) OR "causes of death"[All Fields]) OR ("data collection"[MeSH Terms] OR ("data"[All Fields] AND "collection"[All Fields]) OR "data collection"[All Fields]) OR ("epidemiologic measurements"[MeSH Terms] OR ("epidemiologic"[All Fields] AND "measurements"[All Fields]) OR "epidemiologic measurements"[All Fields]) OR ("epidemiologic methods"[MeSH Terms] OR ("epidemiologic"[All Fields] AND "methods"[All Fields]) OR "epidemiologic methods"[All Fields]) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "epidemiology"[MeSH Terms]) OR ("health surveys"[MeSH Terms] OR ("health"[All Fields] AND "surveys"[All Fields]) OR "health surveys"[All Fields]) OR ("health status indicators"[MeSH Terms] OR ("health"[All Fields] AND "status"[All Fields] AND "indicators"[All Fields]) OR "health status indicators"[All Fields]) OR ("hospital mortality"[MeSH Terms] OR ("hospital"[All Fields] AND "mortality"[All Fields]) OR "hospital mortality"[All Fields]) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "incidence"[All Fields] OR "incidence"[MeSH Terms]) OR ("life expectancy"[MeSH Terms] OR ("life"[All Fields] AND "expectancy"[All Fields]) OR "life expectancy"[All Fields]) OR ("medical records"[MeSH Terms] OR ("medical"[All Fields] AND "records"[All Fields]) OR "medical records"[All Fields]) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "morbidity"[All Fields] OR "morbidity"[MeSH Terms]) OR ("mortality"[Subheading] OR "mortality"[All Fields] OR "mortality"[MeSH Terms]) OR ("mortality, premature"[MeSH Terms] OR ("mortality"[All Fields] AND "premature"[All Fields]) OR "premature mortality"[All Fields] OR ("mortality"[All Fields] AND "premature"[All Fields]) OR "mortality, premature"[All Fields]) OR ("odds ratio"[MeSH Terms] OR ("odds"[All Fields] AND "ratio"[All Fields]) OR "odds ratio"[All Fields]) OR ("population surveillance"[MeSH Terms] OR ("population"[All Fields] AND "surveillance"[All Fields]) OR "population surveillance"[All Fields]) OR ("public health"[MeSH Terms] OR ("public"[All Fields] AND "health"[All Fields]) OR "public health"[All Fields]) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "prevalence"[All Fields] OR	2,175,388	06/13/2012

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
		"prevalence"[MeSH Terms]) OR ("questionnaires"[MeSH Terms] OR "questionnaires"[All Fields]) OR ("risk factors"[MeSH Terms] OR ("risk"[All Fields] AND "factors"[All Fields]) OR "risk factors"[All Fields]) OR ("statistics and numerical data"[Subheading] OR ("statistics"[All Fields] AND "numerical"[All Fields] AND "data"[All Fields]) OR "statistics and numerical data"[All Fields]) OR ("survival rate"[MeSH Terms] OR ("survival"[All Fields] AND "rate"[All Fields]) OR "survival rate"[All Fields]) OR ("vital statistics"[MeSH Terms] OR ("vital"[All Fields] AND "statistics"[All Fields]) OR "vital statistics"[All Fields]) OR ("health care surveys"[MeSH Terms] OR ("health"[All Fields] AND "care"[All Fields] AND "surveys"[All Fields]) OR "health care surveys"[All Fields] OR ("national"[All Fields] AND "hospital"[All Fields] AND "discharge"[All Fields] AND "survey"[All Fields]) OR "national hospital discharge survey"[All Fields]) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "occurrence"[All Fields] OR "epidemiology"[MeSH Terms] OR "occurrence"[All Fields]) OR ("Statistics (Ber)"[Journal] OR "statistics"[All Fields]) OR ("data collection"[MeSH Terms] OR ("data"[All Fields] AND "collection"[All Fields]) OR "data collection"[All Fields] OR "survey"[All Fields]) AND (("2002/01/01"[PDAT] : "2012/12/31"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])		
69	Combine	#60 and #68	5,523	06/13/2012
70	Stimulant use PubMed	("central nervous system stimulants"[MeSH Terms] OR ("central"[All Fields] AND "nervous"[All Fields] AND "system"[All Fields] AND "stimulants"[All Fields]) OR "central nervous system stimulants"[All Fields] OR "central nervous system stimulants"[Pharmacological Action]) OR ("amphetamines"[MeSH Terms] OR "amphetamines"[All Fields]) OR ("caffeine"[MeSH Terms] OR "caffeine"[All Fields]) OR ("cocaine"[MeSH Terms] OR "cocaine"[All Fields]) OR ("methamphetamine"[MeSH Terms] OR "methamphetamine"[All Fields]) OR ("coffee"[MeSH Terms] OR "coffee"[All Fields]) OR Meth[All Fields] OR Uppers[All Fields] OR ("methylphenidate"[MeSH Terms] OR "methylphenidate"[All Fields] OR "ritalin"[All Fields]) OR ("Adderall"[Supplementary Concept] OR "Adderall"[All Fields] OR "adderall"[All Fields]) OR ("dextroamphetamine"[MeSH Terms] OR "dextroamphetamine"[All Fields] OR "dexedrine"[All Fields]) OR ("methamphetamine"[MeSH Terms] OR "methamphetamine"[All Fields] OR "desoxyn"[All Fields]) OR Bilobil[All Fields] OR "Herbal stimulant"[All Fields] OR "herbal stimulants"[All Fields] OR "energy drink"[All Fields] OR "energy drinks"[All Fields] OR ("central nervous system stimulants"[MeSH Terms] OR ("central"[All Fields] AND "nervous"[All Fields] AND "system"[All Fields] AND "stimulants"[All Fields]) OR "central nervous system stimulants"[All Fields] OR "stimulant"[All Fields] OR "central nervous system stimulants"[Pharmacological Action]) OR stimulants[All Fields] OR energy[All Fields] AND (("2002/01/01"[PDAT] : "2012/12/31"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])	90,267	06/13/2012
71	Combine	#60 and #70	171	06/13/2012

Searched 1/1/2002 – 8/1/2012

Key Question 4

The search strategies utilized combinations of free text keywords, as well as controlled vocabulary terms, including (but not limited to) the following concepts: acute fatigue, fatigue, meta-analysis, and review.

PubMed, TRIS, Virginia Tech Transportation Institute

Set Number	Concept & Database	Search Statement	Number Identified	Date Searched
75	Acute fatigue PubMed	"acute fatigue"[All Fields] AND ("humans"[MeSH Terms] AND (Review[ptyp] OR systematic[sb] OR Meta-Analysis[ptyp]) AND English[lang])	4	06/14/2012
76	Fatigue PubMed	("fatigue"[MeSH Terms] OR "fatigue"[All Fields]) AND ("humans"[MeSH Terms] AND (Review[ptyp] OR Meta-Analysis[ptyp] OR systematic[sb]) AND English[lang])	6,260	06/14/2012
77	Eliminate duplicates		6,255 studies remain	06/16/2012

Appendix B: Retrieval Criteria

Listed below are the retrieval criteria that each identified publication had to appear to satisfy based on title and abstract review to be retrieved in full.

All Key Question

- Article must have been published in the English language.
- Article must assess adults aged at least 18 years.
- Study participants must be generally healthy; studied fatigue or sleepiness must be non-pathological.
- Article must appear to be a full-length publication.

Key Question 1

- Article must have enrolled 10 or more drivers.
- Article must assess crash and/or driving ability and its relationship with non-pathological fatigue.
- Article must be an original research study with a comparison or control group of comparable non-fatigued drivers, or compare outcomes when one group of drivers are fatigued and non-fatigued.

Key Question 2

- Article must have enrolled 10 or more drivers.
- Article must be an original research study.

- Article must address the amount of rest needed for fatigued drivers to reach pre-fatigue functioning, fatigue, or sleepiness levels.

Key Question 3

- Article must have enrolled 10 or more people.
- Article must be a study conducted in the United States and published in the past 10 years.

Appendix C: Inclusion Criteria

Listed below are the inclusion criteria for each key question that had to be satisfied based upon full review of retrieved studies for an article to be included in the evidence base.

Inclusion Criteria for All Key Questions

- Article must have been published in the English language.
- Article must be a full-length article. Abstracts and letters to the editor did not meet this inclusion criterion.
- Article must have enrolled 10 or more adults aged at least18 years.
- If the same study is reported in multiple publications, the most complete publication will be the primary reference. Data will be extracted to avoid double-counting individuals.

Key Question 1

- Article must address the key question and either crash or driving ability.
- Study must evaluate actual, not projected or estimated, crash data.
- To address fatigue or sleepiness and crash in healthy drivers, the study must assess the relationship of non-pathologic fatigue and crash in drivers who are specifically stated as being free from any potentially confounding medical, sleep, or other health issue. Article must describe a study that includes a comparison group composed of comparable drivers who do not have non-pathological fatigue, or compare outcomes in the same group of drivers when fatigued and not fatigued.
- To address crash and driving patterns in professional drivers, the study must assess the potential relationship between driving patterns and crash in professional drivers.

Key Question 2

- Article must address the amount of rest needed for professional drivers suffering from non-pathological fatigue to reach pre-fatigue functioning, fatigue, or sleepiness levels.
- In studies with control or comparison group, outcomes of at least five people must have been assessed in each group.

Key Question 3

- Article must be a study conducted in the United States.
- Article must be a study conducted in the past 10 years.

Additional Criteria for Key Question 3A

- Article must have enrolled 50 or more people.
- Article must provide demographic data with one or more of the following attributes:
    - Sex
    - Race
    - Age
    - Education
    - Income
    - Marital status
    - Driving experience

Additional Criteria for Key Question 3B

- Article must have enrolled 10 or more people.
- Article must provide information on commercial driver job function with one or more of the following attributes:
    - Pre-trip operations
    - Distances travelled
    - Roads travelled
    - Control over trip
    - Loading requirements
    - Driving time per day
    - Paperwork
    - Opportunities for rest
    - Distractions

Additional Criteria for Key Question 3C

- Article must have enrolled 10 or more people.
- Article must provide information on commercial driver work environment with one or more of the following attributes:
    - Interactions with passengers
    - Cabin ergonomics
    - Scheduling
    - Shift cycles
    - Interactions with other road users

- Commute times
- Violations
- Potential exposure to harmful substances through performance of duties
- Quality of rest/sleep
- Opportunity for exercise
- Access to health care
- Employer/industry culture

Additional Criteria for Key Question 3D

- Article must have enrolled 10 or more people.
- Article must provide information on commercial driver health-related behaviors/ characteristics with one or more of the following attributes:
    - Smoking status
    - Body mass index/obesity
    - Physical activity/inactivity
    - Use of stimulants, eg, caffeine
    - Alcohol use
    - General health assessment
- Article must provide information on commercial driver disease or disorder with one or more of the following disease characteristics:
    - Cancer
    - Cardiovascular disease
    - Cerebrovascular disease
    - Respiratory disease
    - Chronic kidney disease
    - Endocrine disease
    - Neurological disease
    - Musculoskeletal disease
    - Renal disease
    - Vision loss
    - Hearing loss
    - Mental health and suicide

Key Question 4

- Article must be a review article that provides or summarizes data for risk factors of acute fatigue.
- Article must have been published or dated no earlier than 1990.

Appendix D: Excluded Articles

Table D-1. Excluded studies (Key Question 1A: Crash)

Reference	Reason for Exclusion
Abdullah, D.N.M.A., Von H.L. (2011) "Factors of Fatigue and Bus Accident." 2011 International Conference on Innovation, Management and Service IPEDR vol.14(2011)	Does not address the key question
Abe, T., Y. Komada, et al. (2010). "Short sleep duration and long spells of driving are associated with the occurrence of Japanese drivers' rear-end collisions and single-car accidents." J Sleep Res 19(2): 310-316	Health status of drivers not reported, does not address professional driving patterns
Abe, T., Y. Komada, et al. (2011). "Questionnaire-based evidence of association between sleepiness while driving and motor vehicle crashes that are subjectively not caused by falling asleep." Sleep and Biological Rhythms 9(3): 134-143	Health status of drivers not reported, does not address professional driving patterns
ADTSEA "Traffic Citations According to Selected Demographics, Behaviors, and Injury Severity Factors among Drivers Involved in Crashes in Utah " The Chronicle for Driver Education Professionals Summer 2011 (8)	Not a study with original data
Åkerstedt, T., B. Peters, et al. (2005). "Impaired alertness and performance driving home from the night shift: A driving simulator study." Journal of Sleep Research 14(1): 17-20	No relevant outcome data reported
Åkerstedt, T., J. Connor, et al. (2008). "Predicting road crashes from a mathematical model of alertness regulation--The Sleep/Wake Predictor." Accident Analysis and Prevention 40(4): 1480-1485	Modeled outcomes data only
Akerstedt, T., P. Philip, et al. (2011). "Sleep loss and accidents--work hours, life style, and sleep pathology." Prog Brain Res 190: 169-188	Not a study with original data
Al-Hemoud, A. M., R. J. Simmons, et al. (2010). "Behavior and lifestyle characteristics of male Kuwaiti drivers." J Safety Res 41(4): 307-313	Does not address the key question
Arati , E. "Drowsiness and Fatigue, The Most Frequent Causes of Sever Accidents Among Heavy Vehicle Drivers in Iran" 3rd international conference on traffic and transport psychology (ICTTP 2004)	No relevant outcome data reported
Asaoka, S., K. Namba, et al. (2010). "Excessive Daytime Sleepiness Among Japanese Public Transportation Drivers Engaged in Shiftwork." Journal of Occupational and Environmental Medicine 52(8): 813-818 810.1097/JOM.1090b1013e3181ea1095a1067	No relevant outcome data reported
Asbridge, M., Hayden J.A., Cartwright, J.L. "Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis" BMJ 2012;344:e536 doi: 10.1136/bmj.e536 (Published 9 February 2012)	Confounding factor (drivers smoked cannabis)
Aworemi, J.R., et al. "EFFICACY OF DRIVERS' FATIGUE ON ROAD ACCIDENT IN SELECTED SOUTHWESTERN STATES OF NIGERIA" International Business Research Vol. 3, No. 3; July 2010	No relevant outcome data reported
Beilock, R. (1995). "Schedule-induced hours-of-service and speed limit violations among tractor-trailer drivers." Accid Anal Prev 27(1): 33-42	No relevant outcome data reported
Blanco (2011). The Impact of Driving, Non-Driving Work, and Rest Breaks on Driving Performance in Commercial Motor Vehicle Operations	No relevant outcome data reported
Blower, D., et al. " Bus Operator Types and Driver Factors in Fatal Bus Crashes: Results from the Buses Involved in Fatal Accidents Survey " FMCSA-RRA-09-041 (2008)	Does not address the key question
Boufous, S. and A. Williamson (2006). "Work-related traffic crashes: A record linkage study." Accident Analysis & Prevention 38(1): 14-21	Does not address the key question
Boufous, S. and A. Williamson (2009). "Factors affecting the severity of work related traffic crashes in	Does not address the key question

Reference	Reason for Exclusion
drivers receiving a worker's compensation claim." Accident Analysis & Prevention 41(3): 467-473	
Braver, E. R., C. W. Preusser, et al. (1992). "Long hours and fatigue: a survey of tractor-trailer drivers." J Public Health Policy 13(3): 341-366	No relevant outcome data reported
Brodie, L., B. Lyndal, et al. (2009). "Heavy vehicle driver fatalities: Learning's from fatal road crash investigations in Victoria." Accident Analysis & Prevention 41(3): 557-564	Not a study with original data
Bunn, T. L., S. Slavova, et al. (2005). "Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries." Accident Analysis & Prevention 37(5): 862-869	Does not address the key question
Caird, J. and T. Kline (2004). "The relationships between organizational and individual variables to on-the-job driver accidents and accident-free kilometres." Ergonomics 47(15): 1598-1613	Does not address the key question
Carter, N., J. Ulfberg, et al. (2003). "Sleep debt, sleepiness and accidents among males in the general population and male professional drivers." Accident Analysis & Prevention 35(4): 613-617	Does not address the key question
Caruso, C., et al., Overtime and extended work shifts: Recent findings on illnesses, injuries, and health behaviors, 2004, NIOSH.	Not a study with original data
Chipman, M. and Y. L. Jin (2009). "Drowsy drivers: The effect of light and circadian rhythm on crash occurrence." Safety Science 47(10): 1364-1370	Health status of drivers not reported, does not address professional driving patterns
Chiron, M., M. Bernard, et al. (2008). "Tiring job and work related injury road crashes in the GAZEL cohort." Accident Analysis and Prevention 40(3): 1096-1104	Does not address the key question
Chung, Y.S., Wong, J.S." Developing effective professional bus driver health programs: An investigation of self-rated health" Accident Analysis and Prevention 43 (2011) 2093– 2103	No relevant outcome data reported
Clark, D.D. et al. "An In-depth Study of Work-related Road Traffic Accidents" Department for Transport: London. Road Safety Research Report No. 58. (2005)	Does not address the key question
Clarke, D. D., P. Ward, et al. (2009). "Work-related road traffic collisions in the UK." Accident Analysis & Prevention 41(2): 345-351	Does not address the key question
Connor, J., et al., The role of driver sleepiness in car crashes: a systematic review of epidemiological studies. Accid Anal Prev, 2001. 33(1): p. 31-41.	Not a study with original data
Connor, J., et al., Driver sleepiness and risk of serious injury to car occupants: population based case control study. BMJ, 2002. 324(7346): p. 1125.	Health status of drivers not reported, does not address professional driving patterns
Corfitsen, M. T. (1986). "Fatigue in single car fatal accidents." Forensic Sci Int 30(1): 3-9	Does not address the key question
Corfitsen, M. T. (1989). "Fatigue in multiple-car fatal accidents." Forensic Sci Int 40(2): 161-169	Does not address the key question
Costa, G., et al., Health conditions of bus drivers in a 6 year follow up study. J Hum Ergol (Tokyo), 2001. 30(1-2): p. 405-10.	No relevant outcome data reported
Craft, R., Faitgue and the large truck crash causation study, in Paper presented and distributed at the November2005.	Does not address the key question
Crummy, F., P. A. Cameron, et al. (2008). "Prevalence of sleepiness in surviving drivers of motor vehicle collisions." Internal Medicine Journal 38(10): 769-775	Does not address the key question
Cummings, P., T. D. Koepsell, et al. (2001). "Drowsiness, counter-measures to drowsiness, and the risk of a motor vehicle crash." Injury Prevention 7(3): 194-199	Health status of drivers not reported, does not address professional driving

Reference	Reason for Exclusion
	patterns
Dalziel, J. R. and R. F. Job (1997). "Motor vehicle accidents, fatigue and optimism bias in taxi drivers." Accid Anal Prev 29(4): 489-494	Does not address the key question
de Pinho, R. S. N., F. P. da Silva-Júnior, et al. (2006). "Hypersomnolence and accidents in truck drivers: A cross-sectional study." Chronobiology International 23(5): 963-971	Does not address the key question
Dembe, A. E., J. B. Erickson, et al. (2005). "The impact of overtime and long work hours on occupational injuries and illnesses: new evidence from the United States." Occup Environ Med 62(9): 588-597	No relevant outcome data reported
Dembe, A. E., J. B. Erickson, et al. (2006). "Nonstandard shift schedules and the risk of job-related injuries." Scand J Work Environ Health 32(3): 232-240	No relevant outcome data reported
Dharmaratne, S. D. and M. Stevenson (2006). "Public road transport crashes in a low income country." Inj Prev 12(6): 417-420	Does not address the key question
Dinges, D. F. (1995). "An overview of sleepiness and accidents." J Sleep Res 4(S2): 4-14	Not a study with original data
Dingus, T. A., V. L. Neale, et al. (2006). "The development of a naturalistic data collection system to perform critical incident analysis: an investigation of safety and fatigue issues in long-haul trucking." Accid Anal Prev 38(6): 1127-1136	No relevant outcome data reported
Dingus, T.A., The impact of driver performance and behavior on vehicular safety and crash risk, Virginia Tech Transportation Institute	Not a study with original data
Staff, A.T.S.B., et al., Fatigue Related Crashes: An Analysis of Fatigue Related Crashes on Australian Roads Using an Operational Definition of Fatigue, 2002, Australian Transport Safety Bureau.	Health status of drivers not reported, does not address professional driving patterns
Dorn, L. and A. Af Wåhlberg (2008). "Work-Related Road Safety: An Analysis Based on U.K. Bus Driver Performance." Risk Analysis 28(1): 25-35	Does not address the key question
Dorrian, J., M. Sweeney, et al. (2011). "Modeling fatigue-related truck accidents: Prior sleep duration, recency and continuity." Sleep and Biological Rhythms 9(1): 3-11	Modeled outcomes data only
Dorrian, J. and D. Dawson, Modeling the relationship between sleep/wake history and fatigue-related truck accidents, in International Conference on Fatigue Management in Transportation 2005: Seattle, Washington.	Modeled outcomes data only
Drake, C., T. Roehrs, et al. (2010). "The 10-year risk of verified motor vehicle crashes in relation to physiologic sleepiness." Sleep 33(6): 745-752	Does not address the key question
NCSDR/NHTSA: Expert Panel on Driver Fatigue and Sleepiness “Drowsy Driving and Automobile Crashes” (2002)	Not a study with original data
Edmundo, R.M., et al. “Accidentes de carretera y su relación con cansancio y somnolencia en conductores de omnibus” Rev Med Hered 20 (2), 2009	Not English-language
ETSC “THE ROLE OF DRIVER FATIGUE IN COMMERCIAL ROAD TRANSPORT CRASHES” European Transport Safety Council (2001)	Not a study with original data
IRU “"ETAC" European Truck Accident Causation” European Commission Directorate General for Energy and Transport 2007 IRU I-0145-1 (e)	Health status of drivers not reported, does not address professional driving patterns

Reference	Reason for Exclusion
Friswell, R., Williamson, A. "Work Characteristics Associated with Injury Among Light/Short-Haul Transport Drivers." Accident Analysis and Prevention 42 (2010) 2068-2074	No relevant outcome data reported
Gander, P.H., et al., Sleep, sleepiness and motor vehicle accidents: a national survey. Aust N Z J Public Health, 2005. 29(1): p. 16-21.	Health status of drivers not reported, does not address professional driving patterns
Gander, P. H., N. S. Marshall, et al. (2006). "Investigating driver fatigue in truck crashes: Trial of a systematic methodology." Transportation Research Part F: Traffic Psychology and Behaviour 9(1): 65-76	Health status of drivers not reported, does not address professional driving patterns
Gabarino (2004). "Professional shift-work drivers who adopt prophylactic naps can reduce the risk of car accidents during night work." Sleep 27(7): 1295-1302	Does not address the key question
Garbarino, S., L. Nobili, et al. (2001). "The contributing role of sleepiness in highway vehicle accidents." Sleep: Journal of Sleep Research & Sleep Medicine 24(2): 203-206	Health status of drivers not reported, does not address professional driving patterns
Gnardellis, C., G. Tzamalouka, et al. (2008). "An investigation of the effect of sleepiness, drowsy driving, and lifestyle on vehicle crashes." Transportation Research Part F: Traffic Psychology and Behaviour 11(4): 270-281	Does not address the key question
Guena, S., Ravazzani, R., Perassi, M." Influence of Fatigue in Nonfatal Nighttime Car Accidents Involving Young Males" Istituto di Ricerche Mediche e Psicologiche "Ernesto Lugaro" Via Prarostino n.11, Torino, Italy	Not a study with original data
Grigo, J.A.L, Baldock, M.R.J. "Sleepiness and road crashes: Challenges of definition and measurement" Center for Automotive Safety Research. CASR REPORT SERIES CASR082 July 2011	Not a study with original data
Hakkanen, H. and H. Summala (2001). "Fatal traffic accidents among trailer truck drivers and accident causes as viewed by other truck drivers." Accid Anal Prev 33(2): 187-196	Health status of drivers not reported, does not address professional driving patterns
Hall, R. W. and A. Mukherjee (2008). "Bounds on effectiveness of driver hours-of-service regulations for freight motor carriers." Transportation Research Part E: Logistics and Transportation Review 44(2): 298-312	Modeled outcomes data only
Hamelin, P. (1987). "Lorry driver's time habits in work and their involvement in traffic accidents." Ergonomics 30(9): 1323-1333	Health status of drivers not reported, does not address professional driving patterns
Hanowski, R.J., et al., Impact of Local/Short Haul Operations on Driver Fatigue, 2000, Virginia Tech Transportation Institute.	No relevant outcome data reported
Hanowski, R. J., W. W. Wierwille, et al. (2003). "An on-road study to investigate fatigue in local/short haul trucking." Accident Analysis & Prevention 35(2): 153-160	No relevant outcome data reported
Hanowski, R.J., et al., Analysis of Risk as a Function of Driving Hour: Assessment of Driving Hours 1 Through 11, 2007, US Department of Transportation. p. 38.	No relevant outcome data reported
Hanowski, R.J., et al., Analysis of Risk as a Function of Driving Hour: Assessment of Driving Hours 1 Through 11: Final Report, 2008, US Department of Transportation. p. 98.	No relevant outcome data reported
Hanowski, R. J., J. S. Hickman, et al. (2009). "Evaluating the 2003 revised hours-of-service regulations for truck drivers: The impact of time-on-task on critical incident risk." Accident Analysis & Prevention 41(2): 268-275	No relevant outcome data reported

Reference	Reason for Exclusion
Hansotia, P. (1997). "Sleep, sleep disorders and motor vehicle crashes." Wis Med J 96(5): 42-47	Not a study with original data
Harris, W. (1977). Fatigue, circadian rhythm and truck accidents. Vigilance, Theory, Operational Performance, and Physiological Correlates: 133-146	Health status of drivers not reported, does not address professional driving patterns
Heaton, K., Sleep and motor vehicle crash risk. J Emerg Nurs, 2009. 35(4): p. 363-5.	Not a study with original data
Hertz, R. P. (1991). "Hours of service violations among tractor-trailer drivers." Accident Analysis & Prevention 23(1): 29-36	No relevant outcome data reported
Hickman, J. et al." DISTRACTION IN COMMERCIAL TRUCKS AND BUSES: ASSESSING PREVALENCE AND RISK IN CONJUNCTION WITH CRASHES AND NEAR-CRASHES" FMCSA DTMC75-09-J-00045	Does not address the key question
Hijar, M., C. Carrillo, et al. (2000). "Risk factors in highway traffic accidents: a case control study." Accid Anal Prev 32(5): 703-709	Does not address the key question
Horne, J. and L. Reyner (1999). "Vehicle accidents related to sleep: a review." Occup Environ Med 56(5): 289-294	Not a study with original data
Horne, J.A. and L.A. Reyner, Sleep related vehicle accidents. BMJ, 1995. 310(6979): p. 565-7.	Does not address the key question
Howard, M. E., A. V. Desai, et al. (2004). "Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers." American Journal of Respiratory & Critical Care Medicine 170(9): 1014-1021	Does not address the key question
Ingre, M., T. ÅKerstedt, et al. (2006). "Subjective sleepiness, simulated driving performance and blink duration: examining individual differences." Journal of Sleep Research 15(1): 47-53	No relevant outcome data reported
Jayatilleke, A. U., S. Nakahara, et al. (2009). "Working conditions of bus drivers in the private sector and bus crashes in Kandy district, Sri Lanka: a case–control study." Injury Prevention 15(2): 80-86	Health status of drivers not reported, does not address professional driving patterns
Jensen, A. (2009). "Truck drivers hours-of-service regulations and occupational health " Work: A Journal of Prevention, Assessment and Rehabilitation Volume 33(Number 3): 363-368	No relevant outcome data reported
Kanaan, A., P. Huertas, et al. (2009). "Incidence of different health factors and their influence on traffic accidents in the province of Madrid, Spain." Legal Medicine 11, Supplement 1(0): S333-S336	Does not address the key question
Kanazawa, H., M. Suzuki, et al. (2006). "Excess workload and sleep-related symptoms among commercial long-haul truck drivers." Sleep and Biological Rhythms 4(2): 121-128	No relevant outcome data reported
Kaneko, T., Jovanis, P.P. "Multiday Driving Patterns and Motor Carrier Accident Risk" Accid. Anal. And Prev. Vol. 24, No. 5 (1992)	Modeled outcomes data only
Kishida, K. (1981). "Subsidiary behavior of truck drivers in rear-end collisions." Journal of Human Ergology 10(1)	Not a study with original data
Klauer, S.G. et al. "THE EFFECTS OF FATIGUE ON DRIVER PERFORMANCE FOR SINGLE AND TEAM LONG-HAUL TRUCK DRIVERS" PROCEEDINGS of the Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design (2002)	No relevant outcome data reported
Knauth, P. (2007). "Extended work periods." Ind Health 45(1): 125-136	Not a study with original data
Labbafinejad, K.S.Y., Sleepiness Among Iranian Lorry Drivers. Acta Medica Iranica, 2007. 45(2).	Health status of drivers not reported, does not address professional driving

Reference	Reason for Exclusion
	patterns
Lam, L.T., Environmental factors associated with crash-related mortality and injury among taxi drivers in New South Wales, Australia. Accid Anal Prev, 2004. 36(5): p. 905-8.	Does not address the key question
Langlois, P. H., M. H. Smolensky, et al. (1985). "Temporal patterns of reported single-vehicle car and truck accidents in Texas, U.S.A. during 1980–1983." Chronobiology International 2(2): 131-146	Does not address the key question
Lardelli-Claret, P., J. J. Jiménez-Moleón, et al. (2003). "Association of main driver-dependent risk factors with the risk of causing a vehicle collision in Spain, 1990-1999." Annals of Epidemiology 13(7): 509-517	Health status of drivers not reported, does not address professional driving patterns
Laube, I., R. Seeger, et al. (1998). "Accidents related to sleepiness: review of medical causes and prevention with special reference to Switzerland." Schweiz Med Wochenschr 128(40): 1487-1499	Not a study with original data
Lauber, J.K. and P.J. Kayten, Sleepiness, circadian dysrhythmia, and fatigue in transportation system accidents. Sleep, 1988. 11(6): p. 503-12.	Not a study with original data
Leechawengwongs, M., E. Leechawengwongs, et al. (2006). "Role of drowsy driving in traffic accidents: a questionnaire survey of Thai commercial bus/truck drivers." J Med Assoc Thai 89(11): 1845-1850	Health status of drivers not reported, does not address professional driving patterns
Linklater, D.R., “Fatigue and Long Distance Truck Drivers” Volume 10, Part 4, 1(1980)	Health status of drivers not reported, does not address professional driving patterns
Liu, G. F., S. Han, et al. (2003). "Driver sleepiness and risk of car crashes in Shenyang, a Chinese northeastern city: population-based case-control study." Biomed Environ Sci 16(3): 219-226	Health status of drivers not reported, does not address professional driving patterns
Lombardi, D. A. (2010). "'The case-crossover study: A novel design in evaluating transient fatigue as a risk factor for road traffic accidents': Comments." Sleep: Journal of Sleep and Sleep Disorders Research 33(3): 283-284	Not a study with original data
Lucidi, F., P. M. Russo, et al. (2006). "Sleep-related car crashes: risk perception and decision-making processes in young drivers." Accid Anal Prev 38(2): 302-309	Does not address the key question
Lyznicki, J. M., T. C. Doege, et al. (1998). "Sleepiness, driving, and motor vehicle crashes." JAMA: Journal of the American Medical Association 279(23): 1908-1913	Not a study with original data
Mathis, J. et al. “Excessive daytime sleepiness, crashes and driving Capability” Schweizerarchive Fur Neurologie und Psychiatrie 154-7/2003	Not a study with original data
McGwin, G., Jr. and D. B. Brown (1999). "Characteristics of traffic crashes among young, middle-aged, and older drivers." Accident Analysis and Prevention 31(3): 181-198	Health status of drivers not reported, does not address professional driving patterns
McNoe, B. et al. “Work-related fatal traffic crashes in New Zealand: 1985–1998” Vol 118 No 1227 ISSN 1175 8716	Does not address the key question
Mohamed, N., M.-F. Mohd-Yusoff, et al. (2012). "Fatigue-related crashes involving express buses in Malaysia: Will the proposed policy of banning the early-hour operation reduce fatigue-related crashes and benefit overall road safety?" Accident Analysis & Prevention 45, Supplement(0): 45-49	Does not address the key question
Molinero, A. et al. “Road users and accident causation. Part 1: Overview and general statistics” TRACE Deliverable 1.1 (2006)	Does not address the key question

Reference	Reason for Exclusion
Moore-Ede, M., A. Heitmann, et al. (2004). "Circadian alertness simulator for fatigue risk assessment in transportation: application to reduce frequency and severity of truck accidents." Aviat Space Environ Med 75(3 Suppl): A107-118	Does not address the key question
Morrow, P. C. and M. R. Crum (2004). "Antecedents of fatigue, close calls, and crashes among commercial motor-vehicle drivers." Journal of Safety Research 35(1): 59-69	Does not address the key question
Nabi, H., A. Gueguen, et al. (2006). "Awareness of driving while sleepy and road traffic accidents: prospective study in GAZEL cohort." Bmj 333(7558): 23	Health status of drivers not reported, does not address professional driving patterns
NHTSA, D., National Motor Vehicle Crash Causation Survey: Report to Congress, 2008, Department of Transportation National Highway Safety Administration: Washington, DC. p. 47.	Health status of drivers not reported, does not address professional driving patterns
Noce, F. et al. "Professional drivers and working time: journey span, rest, and accidents" Sleep science Volume 1 • july/2008	Not a study with original data
Nofal, F. H., A. A. Saeed, et al. (1996). "Aetiological factors contributing to road traffic accidents in Riyadh City, Saudi Arabia." J R Soc Health 116(5): 304-311	Does not address the key question
Ohayon, M. M., M. H. Smolensky, et al. (2010). "Consequences of shiftworking on sleep duration, sleepiness, and sleep attacks." Chronobiology International 27(3): 575-589	Does not address the key question
Olsen, R. "Assessment of Drowsy-Related Critical Incidents and the 2004 Revised Hours-of-Service Regulations" Thesis, Faculty of the Virginia Polytechnic Institute and State University (2006)	No relevant outcome data reported
Öztürk, L., Y. Tufan, et al. (2002). "Self-reported traffic accidents and sleepiness in a professional group of Turkish drivers." Sleep & Hypnosis 4(3): 106-110	Health status of drivers not reported, does not address professional driving patterns
Pack, A. I., A. M. Pack, et al. (1995). "Characteristics of crashes attributed to the driver having fallen asleep." Accident Analysis & Prevention 27(6): 769-775	Health status of drivers not reported, does not address professional driving patterns
Papp, K.K., et al., The effects of sleep loss and fatigue on resident-physicians: a multi-institutional, mixed-method study. Acad Med, 2004. 79(5): p. 394-406.	Does not address the key question
Perez-Chada (2005). "Sleep Habits and Accident Risk Among Truck Drivers: A Cross-Sectional Study in Argentina." Sleep VOLUME 28, ISSUE 09(VOLUME 28, ISSUE 09)	Health status of drivers not reported, does not address professional driving patterns
Peters, R.D. et al., Effects of Partial and Total Sleep Deprivation on Driving Performance" Federal Driving Administration (1999)	No relevant outcome data reported
Petridou, E. and M. Moustaki (2000). "Human factors in the causation of road traffic crashes." Eur J Epidemiol 16(9): 819-826	Not a study with original data
Philip, P., P. Sagaspe, et al. (2010). "Sleep disorders and accidental risk in a large group of regular registered highway drivers." Sleep Medicine 11(10): 973-979	No relevant outcome data reported
Philibert, I. and T. Nasca, 2010 duty hour standards: seeing beyond the numeric limits. Mayo Clin Proc, 2011. 86(7): p. 703; author reply 706-8.	Not a study with original data
Powell, N. B., K. B. Schechtman, et al. (2002). "Sleepy driving: accidents and injury." Otolaryngol Head Neck Surg 126(3): 217-227	Does not address the key question

Reference	Reason for Exclusion
Radun, I. and J. E. Radun (2006). "Seasonal variation of falling asleep while driving: An examination of fatal road accidents." Chronobiol Int 23(5): 1053-1064	Does not address the key question
Radun, I., H. Summala, et al. (2007). "Fatal road accidents among Finnish military conscripts: fatigue-impaired driving." Military Medicine 172(11): 1204-1210	Health status of drivers not reported, does not address professional driving patterns
Razmpa, E. et al. "Urban Bus Drivers' Sleep Problems and Crash Accidents" Indian J Otolaryngol Head Neck Surg (July–September 2011) 63(3):269–273; DOI 10.1007/s12070-011-0235-5	Health status of drivers not reported, does not address professional driving patterns
Mir, M. U., J. Razzak, et al. (2010). "Commercial driver accident research survey." Injury Prevention 16(Suppl 1): A78	Not a study with original data
Transportation Research and Marketing., A REPORT ON THE DETERMINATION AND EVALUATION OF THE ROLE OF FATIGUE IN HEAVY TRUCK ACCIDENTS, 1985.	Health status of drivers not reported, does not address professional driving patterns
Robb, G., S. Sultana, et al. (2008). "A systematic review of epidemiological studies investigating risk factors for work-related road traffic crashes and injuries." Injury Prevention 14(1): 51-58	Not a study with original data
Rogers, A., S. Holmes, et al. (2001). "The effect of shiftwork on driving to and from work." J Hum Ergol 30(1-2): 131-136	Health status of drivers not reported, does not address professional driving patterns
Saccomanno, F.F., M. Yu, and J. Shortreed, Effect of driver fatigue on truck accident rates. Urban Transport and the Environment for the 21st Century, 1995: p. 439-46.	Not a study with original data
Sagberg, F. (1999). "Road accidents caused by drivers falling asleep." Accident Analysis & Prevention 31(6): 639-649	Health status of drivers not reported, does not address professional driving patterns
Schultz , G.G. et al. "A SAFETY ANALYSIS OF FATIGUE AND DROWSY DRIVING IN THE STATE OF UTAH" Utah Department of Transportation Research and Development Division (2007)	Does not address the key question
Scott, L.D., et al., The relationship between nurse work schedules, sleep duration, and drowsy driving. Sleep, 2007. 30(12): p. 1801.	Does not address the key question
Sirois, W. et al. "ASSESSING DRIVER FATIGUE AS A FACTOR IN ROAD ACCIDENTS" Fourth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design (2007)	Does not address the key question
Sivak, M. (1981). "Human factors and highway-accident causation: Some theoretical considerations." Accident Analysis and Prevention 13(2): 61-64	Not a study with original data
Smith, R., L. J. Cook, et al. (2004). "Trends of behavioral risk factors in motor vehicle crashes in Utah, 1992-1997." Accid Anal Prev 36(2): 249-255	Health status of drivers not reported, does not address professional driving patterns
Smolensky, M. H., L. Di Milia, et al. (2011). "Sleep disorders, medical conditions, and road accident risk." Accident Analysis & Prevention 43(2): 533-548	Not a study with original data
Soccolich, S. et al. " Identifying High-Risk Commercial Truck Drivers Using a Naturalistic Approach"	Does not address the key question

Reference	Reason for Exclusion
National Surface Transportation Safety Center for Excellence. 11-UF-012 (2011)	
Soccolich, S., et al. "An analysis of driving and working hour on commercial motor vehicle driver safety using naturalistic data collection" Accident Analysis and Prevention (In Review) (2012)	No relevant outcome data reported
Steele, M.T., et al., The occupational risk of motor vehicle collisions for emergency medicine residents. Acad Emerg Med, 1999. 6(10): p. 1050-3.	Does not address the key question
Stevenson, M. "The Heavy Vehicle Study: a case-control study investigating risk factors for crash in long distance heavy vehicle drivers in Australia" BMC Public Health 2010, 10:162	Not a study with original data
Stuckey, R., D. C. Glass, et al. (2010). "Risk factors for worker injury and death from occupational light vehicles crashes in New South Wales (Australia)." a.m. J Ind Med 53(9): 931-939	Health status of drivers not reported, does not address professional driving patterns
Stutts, J.C., et al. "Why Do People Have Drowsy Driving Crashes? Input from Drivers Who Just Did" University of North Carolina Highway Research Center and University of North Carolina School of Medicine (1999)	Modeled outcomes data only
Stutts, J. C., J. W. Wilkins, et al. (2003). "Driver risk factors for sleep-related crashes." Accident Analysis & Prevention 35(3): 321-331	Health status of drivers not reported, does not address professional driving patterns
Summala, H. and T. Mikkola (1994). "Fatal accidents among car and truck drivers: effects of fatigue, age, and alcohol consumption." Hum Factors 36(2): 315-326	Health status of drivers not reported, does not address professional driving patterns
Symmons, M.A., Haworth, N.L. "The contributions of speeding and fatigue to work-related road crashes" Session: Work-related road safety (2) Monash University Accident Research Centre (2004)	Health status of drivers not reported, does not address professional driving patterns
Tefft, B. C. (2012). "Prevalence of motor vehicle crashes involving drowsy drivers, United States, 1999–2008." Accident Analysis and Prevention 45: 180-186	Health status of drivers not reported, does not address professional driving patterns
Thygerson, S. M., R. M. Merrill, et al. (2011). "Epidemiology of Motor Vehicle Crashes in Utah." Traffic Injury Prevention 12(1): 39-47	Does not address the key question
Thygerson, S. M., R. M. Merrill, et al. (2011). "Comparison of factors influencing emergency department visits and hospitalization among drivers in work and nonwork-related motor vehicle crashes in Utah, 1999–2005." Accident Analysis and Prevention 43(1): 209-213	Does not address the key question
Valent (2010). "A Case-Crossover Study of Sleep and Work Hours and the Risk of Road Traffic Accidents." Sleep Volume: 33(Issue Number: 3): 349-354	Health status of drivers not reported, does not address professional driving patterns
Vaz Fragoso, C. A., K. L. B. Araujo, et al. (2010). "Sleep disturbances and adverse driving events in a predominantly male cohort of active older drivers." Journal of the American Geriatrics Society 58(10): 1878-1884	No relevant outcome data reported
Vennelle, M., H.M. Engleman, and N.J. Douglas, Sleepiness and sleep-related accidents in commercial bus drivers. Sleep Breath, 2010. 14(1): p. 39-42.	Does not address the key question
Wickens, C.M. et al. "Cognitive failures as predictors of driving errors, lapses, and violations" Accident Analysis and Prevention 40 (2008) 1223–1233	No relevant outcome data reported

Reference	Reason for Exclusion
Wiegand, D. M., R. J. Hanowski, et al. (2009). "Commercial Drivers' Health: A Naturalistic Study of Body Mass Index, Fatigue, and Involvement in Safety-Critical Events." Traffic Injury Prevention 10(6): 573-579	Does not address the key question
Williamson, A. and S. Boufous (2007). "A data-matching study of the role of fatigue in work-related crashes." Transportation Research Part F: Traffic Psychology and Behaviour 10(3): 242-253	Health status of drivers not reported, does not address professional driving patterns
Winter, K. "Heavy-Truck Accidents Due to Driver Fatigue Can Be Reduced With Simple Measures, However Parking Capacity Must Eventually Be Increased" Virginia Department of Transportation. Research Synthesis Bibliography No. 15 (2008)	Not a study with original data
Zhao, X. G., Y. F. Ma, et al. (2004). "Epidemiological characteristics of expressway traffic trauma in 2040 cases." Chin J Traumatol 7(5): 308-311	Does not address the key question
Zuzewicz, K., M. Konarska, et al. (2010). "Injured professional drivers in Poland - an analysis of the causes and effects in relation to the time of the road accident." Int J Occup Saf Ergon 16(1): 81-91	No relevant outcome data reported

Table D-2. Excluded studies (Key Question 1B: Driving Ability)

Reference	Reason for Exclusion
AAA Drowsy Driving (see also Tefft, B.) "Asleep at the Wheel: The Prevalence and Impact of Drowsy Driving" AAA Foundation for Traffic Safety (2010) TØI report, Oslo Norway (2003	Does not address the key question
Adams-Guppy, J. and A. Guppy (2003). "Truck driver fatigue risk assessment and management: a multinational survey." Ergonomics 46(8): 763-779	Not a comparative study
Åhsberg, E. (2000). "Dimensions of fatigue in different working populations." Scandinavian Journal of Psychology 41(3): 231-241	Does not address the key question
Amundsen, A.H., Sagberg, F., "Hours of Service Regulations and the Risk of Fatigue- and Sleep-Related Road Accidents" TØI report, Oslo Norway (2003)	Not a study
Anund, A., G. Kecklund, et al. (2008). "The alerting effect of hitting a rumble strip--A simulator study with sleepy drivers." Accident Analysis and Prevention 40(6): 1970-1976	Does not address the key question
Arnold, P. K., L. R. Hartley, et al. (1997). "Hours of work, and perceptions of fatigue among truck drivers." Accident Analysis & Prevention 29(4): 471-477	Not a comparative study
Asaoka, S., K. Namba, et al. (2010). "Excessive Daytime Sleepiness Among Japanese Public Transportation Drivers Engaged in Shiftwork." Journal of Occupational and Environmental Medicine 52(8): 813-818	Does not address the key question
Baas, P. H., S. G. Charlton, et al. (2000). "Survey of New Zealand truck driver fatigue and fitness for duty." Transportation Research Part F: Traffic Psychology and Behaviour 3(4): 185-193.	Does not address the key question
Balkin (2000). "Effects of Sleep Schedules on Commercial Motor Vehicle Driver Performance - Final report." Walter Reed Army Inst. of Research, Washington, DC. Div. of Neuropsychiatry May 2000	Does not address the key question
Baulk, S. D. and A. Fletcher (2012). "At home and away: Measuring the sleep of Australian truck drivers." Accident Analysis & Prevention 45, Supplement(0): 36-40	Does not address the key question
Biggs, H.C. et al. " Fatigue Issues for Metropolitan Bus Drivers: Ramifications of Quantitative & Qualitative Research Findings for Safety Management" (2009)	Does not address the key question
Braeckman, L., R. Verpraet, et al. (2011). "Prevalence and Correlates of Poor Sleep Quality and Daytime Sleepiness in Belgian Truck Drivers." Chronobiology International 28(2): 126-134	Does not address the key question

Reference	Reason for Exclusion
Calhoun, V.D., Pearlson, G.D. "A Selective Review of Simulated Driving Studies: Combining Naturalistic and Hybrid Paradigms, Analysis Approaches, and Future Directions" Neuroimage. 2012 January 2; 59(1): 25–35. doi:10.1016/j.neuroimage.2011.06.037	Not a study
Darwent, D., G. Roach, et al. (2012). "How well do truck drivers sleep in cabin sleeper berths?" Applied Ergonomics 43(2): 442-446	Does not address the key question
Daza, I.G." Drowsiness monitoring based on driver and driving data fusion" 2011 14th International IEEE Conference on Intelligent Transportation Systems Washington, DC, USA. October 5-7, 2011	Does not address the key question
Di Milia, L. "Shift work, sleepiness and long distance driving" Transportation Research Part F 9 (2006) 278–285	Does not address the key question
Diez, J. J., D. E. Vigo, et al. (2011). "Sleep Habits, Alertness, Cortisol Levels, and Cardiac Autonomic Activity in Short-Distance Bus Drivers: Differences Between Morning and Afternoon Shifts." Journal of Occupational and Environmental Medicine 53(7): 806-811	Does not address the key question
Fairclough, S. H. and R. Graham (1999). "Impairment of driving performance caused by sleep deprivation or alcohol: A comparative study." Human Factors 41(1): 118-128	Insufficient information to determine whether the study meets inclusion criteria
Feyer, A. M., A. Williamson, et al. (1997). "Balancing work and rest to combat driver fatigue: An investigation of two-up driving in Australia." Accident Analysis & Prevention 29(4): 541-553	Does not address the research question
Feyer, A.-M. and A. M. Williamson (1995). "The influence of operational conditions on driver fatigue in the long distance road transport industry in Australia." International Journal of Industrial Ergonomics 15(4): 229-235	Does not address the key question
Gershon, P., D. Shinar, et al. (2011). "Usage and perceived effectiveness of fatigue countermeasures for professional and nonprofessional drivers." Accident Analysis & Prevention 43(3): 797-803	Does not address the key question
Gunzelmann, G., L. Richard Moore, et al. (2010). "Sleep loss and driver performance: Quantitative predictions with zero free parameters." Cognitive Systems Research	Does not address the key question
Hakkanen, H. and H. Summala (2000). "Sleepiness at work among commercial truck drivers." Sleep 23(1): 49-57	Drivers had sleep disorder
Hakkanen, H. et al. "Blink Duration as an Indicator of Driver Sleepiness in Professional Bus Drivers" SLEEP, Vol. 22, No. 6, 1999	Not a comparative study
Hanowski, R. J., M. A. Perez, et al. (2005). "Driver distraction in long-haul truck drivers." Transportation Research Part F: Traffic Psychology and Behaviour 8(6): 441-458	Does not address the key question
Hanowski, R.J. "Impact of Local/Short Haul Operations on Driver Fatigue" DOT/FMCSA. DOT-MC-00-203 (2000)	Does not address the key question
Heaton (2008 September). "Identifying Variables That Predict Falling Asleep at the Wheel Among Long-Haul Truck Drivers." AAOHN Journal Volume 56(Issue 9): 379-385	Does not address the key question
Heaton, K. L. and M. K. Rayens (2010). "Feedback actigraphy and sleep among long-haul truck drivers." AAOHN Journal 58(4): 137-145	Does not address the key question
Hentschel, U., C. C. Bijleveld, et al. (1993). Stress-related psychophysiological reactions of truck drivers in relation to anxiety, defense, and situational factors	Does not address the key question
Jones, C. B., J. Dorrian, et al. (2005). "Working hours regulations and fatigue in transportation: A comparative analysis." Safety Science 43(4): 225-252	Not a study
King, Mark (2001) Fatigue and commercial drivers. In Proceedings NRMA Fatigue Conference,	Does not address the key question

Reference	Reason for Exclusion
Sydney, NSW	
Krajewski , J. et al. “STEERING WHEEL BEHAVIOR BASED ESTIMATION OF FATIGUE” PROCEEDINGS of the Fifth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design (2010)	Does not address the key question
Laden, F., J. E. Hart, et al. (2007). "Cause-Specific Mortality in the Unionized U.S. Trucking Industry." Environ Health Perspect 115(8)	Does not address the key question
Larue, G.S. “Predicting Effects of Monotony on Driver’s Vigilance” (Ph.D. Thesis) Centre for Accident Research and Road Safety – Queensland. Queensland University of Technology. (2010)	Does not address the key question
Larue, Gregoire and Rakotonirainy, Andry and Pettitt, Anthony N. (2010) Forecasting negative effects of monotony and sensation seeking on performance during a vigilance task. Journal of the Australasian College of Road Safety	Does not address the key question
Machin, M. A. and P. N. Hoare (2008). "The role of workload and driver coping styles in predicting bus drivers’ need for recovery, positive and negative affect, and physical symptoms." Anxiety, Stress & Coping 21(4): 359-375	Does not address the key question
Mani, K., et al.”Associatoin of Body Mass Index, Sleep Quantity, Sleep Quality, and Sleepiness Among Express Bus Driver” Injury Prevention 2010;16 (Suppl. 1):A1 – A289	Does not address the key question
Maycock, G. (1997). "Sleepiness and driving: the experience of heavy goods vehicle drivers in the UK." Journal of Sleep Research 6(4): 238-244	Does not address research question
Min, H., “The impact of hours-of-service regulations on transportation productivity and safety: a summary of findings from the literature” Journal of Transportation Management. Sept (2009)	Not a study
Mitler, M. M. and C. D. Wylie (1998). "'The sleep of long haul truck drivers': Reply." The New England Journal of Medicine 338(6)	Not a study
Morad, Y., Y. Barkana, et al. (2009). "Ocular parameters as an objective tool for the assessment of truck drivers fatigue." Accident Analysis & Prevention 41(4): 856-860	Does not address the key question
NTC. “EVALUATION SURVEY ON DRIVER FATIGUE A NATIONAL STUDY OF HEAVY VEHICLE OPERATORS” National Transport Commission. Australia. (2007)	Not a comparative study
O’Neill (1999). "Effects of Cargo Loading and Unloading on Truck Driver Alertness " Transportation Research Record: Journal of the Transportation Research Board: 42-48	Does not address the key question
Olsen, R. “Assessment of Drowsy-Related Critical Incidents and the 2004 Revised Hours-of-Service Regulations” Thesis, Faculty of the Virginia Polytechnic Institute and State University (2006)	Does not address the key question
Oron-Gilad, T. and D. Shinar (2000). "Driver fatigue among military truck drivers." Transportation Research Part F: Traffic Psychology and Behaviour 3(4): 195-209	Does not address the key question
Otmani, S., J. Rogé, et al. (2005). "Sleepiness in professional drivers: Effect of age and time of day." Accident Analysis & Prevention 37(5): 930-937	Does not address the key question
Paul, A. et al. “STEERING ENTROPY CHANGES AS A FUNCTION OF MICROSLEEPS” PROCEEDINGS of the Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design (2006)	Drivers had sleep disorder
Perttula, P. I. A., T. Ojala, et al. (2011). "FACTORS IN THE FATIGUE OF HEAVY VEHICLE DRIVERS." Psychological Reports 108(2): 507-514	Does not address the key question
Philip, P. (2005). "Sleepiness of Occupational Drivers." Industrial Health 43(1): 30-33	Not a study
Philip, P., P. Sagaspe, et al. (2010). "Sleep disorders and accidental risk in a large group of regular	Not a study

Reference	Reason for Exclusion
registered highway drivers." Sleep Medicine 11(10): 973-979	
Raggatt (1997). "A Field Study of Stress and Fatigue in Long-Distance Bus Drivers." Behavioral Medicine Volume 23(Issue 3): 122-129	Does not address the key question
Ranney, T. A., L. A. Simmons, et al. (1999). "Prolonged exposure to glare and driving time: Effects on performance in a driving simulator." Accident Analysis and Prevention 31(6): 601-610	< 10 participants
Rigas, G., et al. "Towards Driver's State Recognition on Real Driving Conditions" International Journal of Vehicular Technology Volume 2011, Article ID 617210, 14 pages doi:10.1155/2011/617210 (2011)	Insufficient information to determine whether the study meets inclusion criteria
Sabbagh-Ehrlich, S., L. Friedman, et al. (2005). "Working conditions and fatigue in professional truck drivers at Israeli ports." Injury Prevention 11(2): 110-114	Insufficient information to determine whether the study meets inclusion criteria
Sadeghniiat,K., Labbafinejad, Y. "SLEEPINESS AMONG IRANIAN LORRY DRIVERS" Acta Medica Iranica, 45(2): 149-152; 2007	Does not address the key question
Sandberg, D., A. Anund, et al. (2011). "The characteristics of sleepiness during real driving at night-a study of driving performance, physiology and subjective experience." Sleep 34(10): 1317-1325	Insufficient reporting to determine whether drivers met inclusion criteria
Santos (2010). "Brainstem evoked response in bus drivers with noise-induced hearing loss." Braz J Otorhinolaryngol 75((5)): 753-759	Does not address the key question
Sluiter, J. K. (1999). "The influence of work characteristics on the need for recovery and experienced health: a study on coach drivers." Ergonomics 42(4): 573-583	Does not address the key question
Smiley (1997). "36-HOUR RECOVERY PERIOD FOR TRUCK DRIVERS: SYNOPSIS OF CURRENT SCIENTIFIC KNOWLEDGE.	Not a study
Smith, S. et al. "Sleepiness and Hazard Perception While Driving" University of Queensland ROAD SAFETY GRANT REPORT, No. 2009-001 (2009)	Does not address the key question
Souza (2005). "Sleep habits, sleepiness and accidents among truck drivers." Arq. Neuro-Psiquiatr. vol.63 (no.4)	Does not address the key question
Steff, F., Spradlin, H., "Driver Distraction, Aggression, and Fatigue: A Synthesis of the Literature and Guidelines for Michigan Planning" Michigan Office of Highway Safety Planning (2000)	Not a study
Sullivan, J.S. "VISUAL FATIGUE AND THE DRIVER" University of Michigan Transportation Research Institute. (2008)	Not a study
Taylor, A. H. and L. Dorn (2006). "STRESS, FATIGUE, HEALTH, AND RISK OF ROAD TRAFFIC ACCIDENTS AMONG PROFESSIONAL DRIVERS: The Contribution of Physical Inactivity." Annual Review of Public Health 27(1): 371-391	Does not address the key question
Tzamalouka, G., M. Papadakaki, et al. (2005). "Freight transport and non-driving work duties as predictors of falling asleep at the wheel in urban areas of Crete." Journal of Safety Research 36(1): 75-84	Does not address the key question
Verweny, W.B., Zaidel, D.M. "Predicting drowsiness accidents from personal attributes, eye blinks and ongoing driving behavior" Personality and Individual Di€erences 28 (2000) 123±142	Does not address the key question
Wiegand, D. M., R. J. Hanowski, et al. (2009). "Commercial Drivers' Health: A Naturalistic Study of Body Mass Index, Fatigue, and Involvement in Safety-Critical Events." Traffic Injury Prevention 10(6): 573-579	Does not address the key question
Williamson, A. M., A.-M. Feyer, et al. (1996). "The impact of work practices on fatigue in long distance truck drivers." Accident Analysis & Prevention 28(6): 709-719	Does not address the key question

Reference	Reason for Exclusion
Wu (2011). "Effects of Scheduling on Sleep and Performance in Commercial Motorcoach Operations." Proceedings of the 6th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design, Resort at Squaw Creek, Olympic Valley - Lake Tahoe, California, USA, June 27-30, 2011: 59-65	Not a study
Wylie (1997). "Commercial Motor Vehicles Driver Fatigue, Alertness, and Countermeasures Survey." Essex Corp, Goleta CA	Does not address the key question

Table D-3. Excluded studies (Key Question 2)

Reference	Reason for Exclusion
"National Research Council (U.S.). Committee on the Effects of Commuting on Pilot. The Effects of Commuting on Pilot Fatigue Washington, D.C.: National Academies Press, 2011. http://nyam.waldo.kohalibrary.com/cgi-bin/koha/opac-detail.pl?biblionumber=261036.	Not a full study report
Abrams, C., T. Schultz, and C. D. Wylie. Commercial Motor Vehicle Driver Fatigue, Alertness, and Countermeasures Survey. Washington, D. C.: Federal Highway Administration, 1997.	Does not address the Key Question
Alluisi, E. A. "Influence of Work-Related Scheduling and Sleep Loss on Sustained Performance." In Aspects of Human Efficiency, edited by W. P. Colquhoun. Strasbourg, England: The English Universities Press Ltd., 1972.	Not a population of interest
Alluisi, E. A., and W. D. Chiles. "Sustained Performance, Work-Rest Scheduling, and Diurnal Rhythms in Man." Acta Psychologica (Scandinavia) 27, (1967): 436-442.	Study not available: could not be retrieved
Anonymous. "Fatigue Prevention; Scientists at University of South Australia Publish Research in Fatigue Prevention." Health & Medicine Week, (2008).	Not a population of interest
Author not reported. "Development of a North American Fatigue Management Program for Commercial Motor Carriers Phase 2." Montreal, Quebec, Canada: Transportation Development Centre, 2007.	Not a full study report
Author not reported. "Drivers Air Safety Views." Heavy Duty Trucking 68, no. 9 (1989): 50.	Not a full study report
Author not reported. "National Summit on Drowsy Driving." In National Summit: The Many Faces of Drowsy Driving. Washington, D.C., 2002.	Not a full study report
Author not reported. "The Drive and Rest Time Law as Laid out by the Drive and Rest Time Committee." JULKAISUJA, no. 8 (1989): 16 p.	Not a full study report
Author not reported. Effects of Operating Practices on Commercial Driver Alertness. U.S. Department of Transportation, Federal Highway Administration, 1999, FHWA-MCRT-99-008.	Not a full study report
Author not reported. Investigation of the Recovery Period Required for Commercial Motor Vehicle Drivers with Cumulative Fatigue. Montreal, Quebec, Canada: Transportation Development Centre, 2006.	Not a full study report
Author not reported. Tackling Fatigue: Eu Social Rules and Heavy Goods Vehicle Drivers. Brussels, Belgium: European Transport Safety Council, 2011.	Not a full study report
Banerjee, I., J. ho Lee, K. Jang, S. Pande, and D. Ragland. Rest Areas -- Reducing Accidents Involving Driver Fatigue. Sacramento, CA: California Department of Transportation, 2010.	Does not address the Key Question
Barach, P., G. B. David, and E. Richter. "The Sleep of Long-Haul Truck Drivers." N Engl J Med 338, no. 6 (1998): 390; author reply 391.	Not a full study report
Barr, L., S. Popkin, and H. Howarth. An Evaluation of Emerging Driver Fatigue Detection Measures and Technologies: Final Report. Washington, D.C.: Federal Motor Carrier Safety Administration, 2009, FMCSA-RRR-09-005.	Does not address the Key Question

Reference	Reason for Exclusion
Barton, J., and S. Folkard. "Advancing Versus Delaying Shift Systems." Ergonomics 36, no. 1-3 (1993): 59-64.	Does not address the Key Question
Baulk, S. D. , A. Fletcher, K.J. Kandelaars, D. Dawson, and G. D. Roach. "A Field Study of Sleep and Fatigue in a Regular Rotating 12-H Shift System." Applied Ergonomics 40, no. 4 (2009): 694-698.	Not a population of interest
Beech, E. "Caught Napping." Flight International 140, no. 4278 (1991): 30-31.	Not a full study report
Belenky, Gregory, Steven R. Hursh, J. Fitzpatrick, and H. P. A. Van Dongen. Split Sleeper Berth Use and Driver Performance: A Review of the Literature and Application of a Mathematical Model Predicting Performance from Sleep/Wake History and Circadian Phase. The American Trucking Associations, 2008.	Does not address the Key Question
Blanco, M., R. Hanowski, R. L. Olson, J. F. Morgan, S. A. Soccolich, S-C Wu, and F. Guo. The Impact of Driving, Non-Driving Work, and Rest Breaks on Driving Performance in Commercial Motor Vehicle Operations. Washington, D.C.: Federal Motor Carrier Safety Administration, 2011, FMCSA-RRR-11-017.	Does not address the Key Question
Bonnet, M. H. "Dealing with Shift Work: Physical Fitness, Temperature and Napping." Work & Stress 4, (1990): 261-274.	Study not available: could not be retrieved
Caldwell, J. A. "The Impact of Fatigue in Air Medical and Other Types of Operations: A Review of Fatigue Facts and Potential Countermeasures." Air Med J 20, no. 1 (2001): 25-32.	Not a full study report
Caldwell, J. A., R. W. Jones, J. L. Caldwell, J. A. Colon, A. Pegues, and L. Iverson. The Efficacy of Hypnotic-Induced Prophylactic Naps for the Maintenance of Alertness and Performance in Sustained Operations. Frederick, MD: U.S. Army Medical Research and Material Command, 1997.	Does not address the Key Question
Cameron, C. "A Theory of Fatigue." Ergonomics 16, no. 5 (1973): 633-648.	Not a full study report
Caruso, C. C., E. M. Hitchcock, R. B. Dick, J. M. Russo, and J. M. Schmit. Overtime and Extended Work Shifts: Recent Findings on Illnesses, Injuries, and Health Behaviors. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2004.	Not a population of interest
Co, E. L., K. B. Gregory, J. M. Johnson, and M.R. Rosekind. Crew Factors in Flight Operations Xi: A Survey of Fatigue Factors in Regional Airline Operations. Moffett Field, CA: NASA Ames Research Center, 1999.	Study not available: could not be retrieved
Cullen, David. "When to Drive, When to Sleep." Fleet Owner 102, no. 4 (2007): 20-25.	Not a full study report
Cummings, P., T. D. Koepsell, J. M. Moffat, and F. P. Rivara. "Drowsiness, Counter-Measures to Drowsiness, and the Risk of a Motor Vehicle Crash." Injury Prevention 7, no. 3 (2001): 194-199.	Not a population of interest
David F. Dinges (University of Pennsylvania, Philadelphia, PA); Greg Maislin (University, of Pennsylvania Biomedical Statistical Consulting); Gerald P. Krueger (Krueger, Ergonomics Consultants); Rebecca Brewster (American Transportation Research, and Institute); and Robert J. Carroll (Federal Motor Carrier Safety Administration). Pilot Test of Fatigue Management Technologies. Washington, D.C.: Federal Motor Carrier Safety Administration, 2005, FMCSA-RT-05-002.	Does not address the Key Question
Davis, R. E. L. Commercial Driver Rest and Parking Requirements: Making Space for Safety. 1997.	Does not address the Key Question
Dawson, Drew. "Fatigue Research in 2011: From the Bench to Practice." Accident Analysis & Prevention Volume 45 Supplement, (2012).	Duplicate record
Dawson, Drew. "Fatigue Research in 2011: From the Bench to Practice." Accident Analysis & Prevention Volume 45, no. March 2012 (2011): Pages 1-5.	Not a full study report
de Pinho, Rachel S. N., Francisco P. da Silva-Júnior, João Paulo C. Bastos, Werllen S. Maia, Marco Túlio de Mello, Veralice M. S. de Bruin, and Pedro Felipe C. de Bruin. "Hypersomnolence and	Does not address the Key Question

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Accidents in Truck Drivers: A Cross-Sectional Study." Chronobiology International 23, no. 5 (2006): 963-971.	
Della Rocco, P. S., C. Comeratore, L. Caldwell, and C. Cruz. The Effects of Napping on Night Shift Performance. Oklahoma City, OK: Federal Aviation Administration Civil Aeromedical Institute, 2000.	Not a population of interest
Desmond, P. A., P. A. Hancock, and J. L. Monette. "Fatigue and Automation-Induced Impairments in Simulated Driving Performance." Transportation Research Record: Journal of the Transportation Research Board, no. Volume 1628 / 1998 (1998): 8-14.	Not a population of interest
Di Milia, Lee and Smolensky, Michael H and Costa, Giovanni and Howarth, Heidi D and Ohayon, Maurice M and Philip, Pierre. "Demographic Factors, Fatigue, and Driving Accidents: An Examination of the Published Literature." Accident Analysis & Prevention Volume 43, no. 2 (2011): 516 - 532.	Not a population of interest
Diez, J. J., D. E. Vigo, S. P. Lloret, S. Rigters, N. Role, D. P. Cardinali, and D. P. Chada. "Sleep Habits, Alertness, Cortisol Levels, and Cardiac Autonomic Activity in Short-Distance Bus Drivers: Differences between Morning and Afternoon Shifts." J Occup Environ Med 53, no. 7 (2011): 806-11.	Does not address the Key Question
Dinges, D. R., and G. Maislin. Truck Driver Fatigue Management. Washington, D.C.: Federal Motor Carrier Safety Administration, 2006, FMCSA-RRR-06-008.	Does not address the Key Question
Dorrian, Jillian and Hussey, Frank and Dawson, Drew. "Train Driving Efficiency and Safety: Examining the Cost of Fatigue." Journal of Sleep Research Volume 16, no. Issue 1 (2007): pg 1 - 11.	Does not address the Key Question
Dorrian, Jillian and Roach, Gregory D and Fletcher, Adam and Dawson, Drew. "Simulated Train Driving: Fatigue, Self-Awareness and Cognitive Disengagement." Applied Ergonomics Volume 38, no. Issue 2 (2007): pp. 155 - 166.	Does not address the Key Question
Dorrian, Jillian, Margaret Sweeney, and Drew Dawson. "Modeling Fatigue-Related Truck Accidents: Prior Sleep Duration, Recency and Continuity." Sleep and Biological Rhythms 9, no. 1 (2011): 3-11.	Does not address the Key Question
Eskandarian, A., R. Sayed, D. Delaigue, J. Blum, and A. Mortazavi. Advanced Driver Fatigue Research. Washington, D. C. : Federal Motor Carrier Safety Administration, 2007, FMCSA-RRR-07-001.	Does not address the Key Question
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Ferguson, Sally A., Nicole Lamond, Katie Kandelaars, Sarah M. Jay, and Drew Dawson. "The Impact of Short, Irregular Sleep Opportunities at Sea on the Alertness of Marine Pilots Working Extended Hours." Chronobiology International 25, no. 2-3 (2008): 399-411.	Does not address the Key Question
Feyer, A. M., A. Williamson, and R. Friswell. "Balancing Work and Rest to Combat Driver Fatigue: An Investigation of Two-up Driving in Australia." Accident Analysis & Prevention 29, no. 4 (1997): 541-553.	Does not address the Key Question
Feyer, A., and A. M. Williamson. "Work and Rest in the Long-Distance Road Transport Industry in Australia." Work & Stress 9, no. 2/3 (1995): 198-205.	Does not address the Key Question
Friswell, R., and A. Williamson. "Evaluating Fatigue Management Strategies for Long Distance Road Transport." In Fatigue Management in Transportation Operations. Seattle, WA, 2005.	Not a study
Gander, P. H., R. C Graeber, L. J. Connell, and K. B. Gregory. Crew Factors in Flight Operations Viii: Factors Influencing Sleep Timing and Subjective Sleep Quality in Commercial Long-Haul Fligh Crews. Moffett Field, CA, 1991.	Study not available: could not be retrieved
Gertler, J. , and A. DiFiore. Work Schedules and Sleep Patterns of Railroad Workers. Washington, D.C.: Federal Railroad Administration, 2009.	Does not address the Key Question
Goh, SzeSeen Kee and Shamsul Bahri Mohd Tamrin and YongMeng. "Driving Fatigue and	Not a population of interest

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Hallowell, Matthew R. "Working Fatigue." American Society of Safety Engineers Volume 55, no. 12 (2010): 9 pages.	Not a full study report
Hanowski, R. J., M. A. Perez, and T. A. Dingus. "Driver Distraction in Long-Haul Truck Drivers." Transportation Research Part F: Psychology and Behaviour 8, no. 6 (2005): 441-458.	Does not address the Key Question
Hanowski, R. J., W. W. Wierwille, and T. A. Dingus. "An on-Road Study to Investigate Fatigue in Local/Short Haul Trucking." Accident Analysis & Prevention 35, no. 2 (2003): 153-160.	Study not available: could not be retrieved
Hans, P. A., H. P. A. Van Dongen, and G. Belenky. Investigation into Motor Carrier Practices to Achieve Optimal Commercial Motor Vehicle Driver Performance: Phase I. Washington, D. C. : U. S. Department of Transportation Federal Motor Carrier Safety Administration, 2010.	Does not address the Key Question
Hans, P. A., H. P. A. Van Dongen, M. L. Jackson, and G. Belenky. Duration of Restart Period Needed to Recycle with Optimal Performance. Washington, D. C. : U. S. Department of Transportation, Federal Motor Carrier Safety Administration, 2010.	Does not address the Key Question
Hellerstrom, David. "The Best Rest." AeroSafety world 5, (2010): p. 40-45 : ill.	Does not address the Key Question
Holmes, A., S. Al-Bayat, C. Hilditch, and S. Bourgeois-Bougrine. "Sleep and Sleepiness During an Ultra Long-Range Flight Operation between the Middle East and United States." Accid Anal Prev 45 Suppl, (2012): 27-31.	Does not address the Key Question
Ikeda, H., A. Mihoshi, and M. Nakaseko. "Effects of Nighttime Nap and Daytime Sleep on Heart Rate and Drowsiness in Long-Distance Highway Bus Drivers." IATSS Research 30, no. 2 (2006): 78-82.	Does not address the Key Question
Jay, S. M., D. Dawson, and Nicole Lamond. "Train Drivers' Fatigue & Recovery During Extended Relay Operations." In International Conference on Fatigue Management in Transportation Seattle, WA, 2005.	Insufficient number of participants or records
Jay, Sarah M, Drew Dawson, Sally A Ferguson, and Nicole Lamond. "Driver Fatigue During Extended Rail Operations." Applied Ergonomics Volume 39, no. Issue 5 (2008): pp. 623 - 629.	Study not available: could not be retrieved
Joint, M. ,Howard, A. "Fatigue and Stress in Driving." Employee Counselling Today 6, no. 6 (1994): 3 - 7.	Not a full study report
Jovanis, P. P., T. Kaneko, and T-D. Lin. Exploratory Analysis of Motor Carrier Accident Risk and Daily Driving Pattern. Washington, D.C.: Transportation Research Board, 1991.	Does not address the Key Question
Kecklund, Göran, and Torbjörn ÅKerstedt. "Sleep in a Truck Berth." Sleep: Journal of Sleep Research & Sleep Medicine 20, no. 8 (1997): 614-619.	Does not address the Key Question
Kircher, Katja, and Jan Andersson. "Road Safety in Tanzania: A Questionnaire Study." Road safety on four continents: 15th international conference, Abu Dhabi, United Arab Emirates, 28-30 March 2010. Paper, (2010): s 1093-1104.	Study not available: could not be retrieved
Klauer, S. G., T. A. Dingus, V. L. Neale, and R. J. Carroll. "The Effects of Fatigue on Driver Performance for Single and Team Long-Haul Truck Drivers." In Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, p. 143-147. Park City, UT, 2003.	Does not address the Key Question
Knipling, Ronald R. "The Technologies, Economics, and Psychology of Commercial Motor Vehicle Driver Fatigue Management." In Transportation technology for tomorrow 20 p. Detroit, MI, 1998.	Study not available: could not be retrieved
Krueger, Gerald P. "Research on the Health and Wellness of Commercial Truck and Bus Drivers: Summary of an International Conference." 144p: Transportation Research Board, 2012.	Not a full study report
Krueger, Gerald P., Michael H. Belzer, Albert Alvarez, Ronald R. Knipling, E. Lee Husting, Rebecca	Not a full study report

Reference	Reason for Exclusion
M. Brewster, and John H. Siebert. "Health and Wellness of Commercial Drivers." Transportation Research E-Circular, no. E-C117 (2007): pp 58-91.	
Lamond, Nicole, Renee M. Petrilli, Drew Dawson, and Gregory D. Roach. "The Sleep, Subjective Fatigue, and Sustained Attention of Commercial Airline Pilots During an International Pattern." Chronobiology International 23, no. 6 (2006): pp 1347-1362.	Does not address the Key Question
Lee, Ming. "Examining Large-Truck Crash Risks Attributed to Driver Fatigue and Hours of Sleep." 25p, 2010.	Study not available: could not be retrieved
Leechawengwongs, M., E. Leechawengwongs, C. Sukying, and U. Udomsubpayakul. "Role of Drowsy Driving in Traffic Accidents: A Questionnaire Survey of Thai Commercial Bus/Truck Drivers." J Med Assoc Thai 89, no. 11 (2006): 1845-50.	Does not address the Key Question
Leger, D., P. Philip, P. Jarriault, A. Metlaine, and D. Choudat. "Effects of a Combination of Napping and Bright Light Pulses on Shift Workers' Sleepiness at the Wheel: A Pilot Study." J Sleep Res 18, no. 4 (2009): 472-9.	Insufficient number of participants or records
Lerman, Steven E., Evamaria Eskin, David J. Flower, Eugenia C. George, Benjamin Gerson, Natalie Hartenbaum, Steven R. Hursh, and Martin Moore-Ede. "Fatigue Risk Management in the Workplace." Journal of Occupational & Environmental Medicine 54, no. 2 (2012): 231-258.	Not a full study report
Lin, T., P. Jovanis, and C. Yang. "Modeling the Safety of Driver Service Hours Using Time-Dependent Logistic Regression." Transportation Research Record 1407, (1993): 1-10.	Does not address the Key Question
Lowden, A., and T. Akerstedt. "Eastward Long Distance Flights, Sleep and Wake Patterns in Air Crews in Connection with a Two-Day Layover." J Sleep Res 8, no. 1 (1999): 15-24.	Not a population of interest
Lucidi, Fabio, Alessandra Devoto, Mario Bertini, Paride Braibanti, and Cristiano Violani. "The Effects of Sleep Debt on Vigilance in Young Drivers: An Education/Research Project in High Schools." Journal of Adolescence 25, no. 4 (2002): 405-414.	Not a population of interest
Lyznicki, J. M., T. C. Doege, R. M. Davis, and M. A. Williams. "Sleepiness, Driving, and Motor Vehicle Crashes." JAMA: Journal of the American Medical Association 279, no. 23 (1998): 1908-1913.	Not a full study report
Mabbott, N., and S. Newman. Safety Improvements in Prescribed Driving Hours. Sydney, Australia: Austroads Incorporated, 2001, 0-85588-575-0.	Does not address the Key Question
Macchi, M. M., Z. Boulos, T. Ranney, L. Simmons, and S. S. Campbell. "Effects of an Afternoon Nap on Nighttime Alertness and Performance in Long-Haul Drivers." Accid Anal Prev 34, no. 6 (2002): 825-34.	Insufficient number of participants or records
Machin, M. A., and P. N. Hoare. "The Role of Workload and Driver Coping Styles in Predicting Bus Drivers' Need for Recovery, Positive and Negative Affect, and Physical Symptoms." Anxiety Stress Coping 21, no. 4 (2008): 359-75.	Does not address the Key Question
Malette, R. Shift Study and Assessment of 48 and 72-Hour Rest Breaks. Ontario Hydro HRP and Development, 1994.	Study not available: could not be retrieved
Mani, K., N. Fazelin, and S. Ismail. "Association of Body Mass Index, Sleep Quantity, Sleep Quality and Sleepiness among Express Bus Driver." Injury Prevention 16, (2010): A13-4.	Study not available: could not be retrieved
Maughan, T. "Sweet Dreams?" COMMERCIAL MOTOR 189, no. 4819 (1999): p. 36-7.	Study not available: could not be retrieved
May, Jennifer F and Baldwin, Carryl L. "Driver Fatigue: The Importance of Identifying Causal Factors of Fatigue When Considering Detection and Countermeasure Technologies." Transportation Research Part F: Psychology and Behaviour Volume 12, no. Issue 3 (2009): pp. 218 - 224.	Not a population of interest
Maycock, G. "Sleepiness and Driving: The Experience of Uk Car Drivers." J Sleep Res 5, no. 4 (1996): 229-37.	Not a population of interest

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McCartt, A. T., B. E. Wright, J. W. Rohrbaugh, and M. C. Hammer. "Causes of Sleepiness-Related Driving among Long-Distance Truck Drivers Including Violations of the Hours-of-Service Regulations." p. 155-172: Swedish National Road and Transport Research Institute (VTI), 2000.	Study not available: could not be retrieved
McCartt, A. T., J. W. Rohrbaugh, M. C. Hammer, and S. Z. Fuller. "Factors Associated with Falling Asleep at the Wheel among Long-Distance Truck Drivers." Accid Anal Prev 32, no. 4 (2000): 493-504.	Does not address the Key Question
McCartt, A. T., M. C. Hammer, and S. Z. Fuller. "Work and Sleep/Rest Factors Associated with Driving While Drowsy Experiences among Long-Distance Truck Drivers." p. 95-108: Association for the Advancement of Automotive Medicine, 1997.	Study not available: could not be retrieved
McGuffog, A., M. B. Spencer, C. Turner, and B. Stone. Working Patterns of Train Drivers: Implications for Fatigue and Safety. Rail Safety & Standards Board, 2004.	Does not address the Key Question
McLaren, Grant. "Crew Rest and Duty Days." Professional Pilot 40, no. 10 (2006): p. 128-134 : ill.	Not a full study report
Mello, M. T., M. G. Santana, L. M. Souza, P. C. Oliveira, M. L. Ventura, C. Stampi, and S. Tufik. "Sleep Patterns and Sleep-Related Complaints of Brazilian Interstate Bus Drivers." Braz J Med Biol Res 33, no. 1 (2000): 71-7.	Does not address the Key Question
Miller, Eric. "Fmcsa to Issue Guidance on Treating Sleep Disorders." Transport Topics, no. 3988 (2012): p. 28.	Not a full study report
Mir, M. U., Junaid A. Razzak, and K. Ahmad. "Commercial Driver Accident Research Survey." 16, v.p.: BMJ Publishing Group, 2010.	Study not available: could not be retrieved
Mitler, M. M., J. C. Miller, J. J. Lipsitz, J. K. Walsh, and C. D. Wylie. "The Sleep of Long-Haul Truck Drivers." N Engl J Med 337, no. 11 (1997): 755-61.	Does not address the Key Question
Mitler, M. M., J. C. Miller, J. J. Lipsitz, J. K. Walsh, and C. D. Wylie. " "The Sleep of Long-Haul Truck Drivers." In Managing Fatigue in Transportation. Proceedings of the 3rd Fatigue in Transportation Conference, p. 99-118. Fremantle, Western Australia, 1998.	Does not address the Key Question
Moller, Henry J. "Driver Health and Traffic Safety: An Overview." In Drugs, Driving and Traffic Safety, edited by J.C. Verster, S.R. Pandi-Perumal, J.G. Ramaekers and J.J. de Gier, pp 1-22. Basel, Switzerland: Birkhäuser, 2009.	Not a full study report
Monaco, K, Olsson, L, Hentges, J. "Hours of Sleep and Fatigue in Motor Carriage." Contemporary Economic Policy Volume 23, no. Issue 4 (2005): pp. 615 - 624.	Does not address the Key Question
Moreno, C. R. C., L. Matuzaki, F. Carvalho, R. Alves, I. Pasqua, and G. Lorenzi-Filho. "Truck Drivers Sleep-Wake Time Arrangements." Biological Rhythm Research 34, no. 2 (2003): 137-143.	Does not address the Key Question
Nabi, H., A. Guéguen, M. Zins, E. Lagarde, M. Chiron, and S. Lafont. "Awareness of Driving While Sleepy and Road Traffic Accidents: Prospective Study in Gazel Cohort [Corrected] [Published Erratum Appears in Bmj 2007 Jan 6;334(7583):40]." BMJ: British Medical Journal (International Edition) 333, no. 7558 (2006): 75-77.	Does not address the Key Question
Nazimek, Larry E. "Sleep: It's No Longer Just for Underachievers." AIR LINE PILOT, (2003): 18-23.	Not a full study report
Neale, V. L., G. S. Robinson, T. A. Dingus, and R. E. L. Davis. "Long-Haul Drivers' Perspective on Sleeper Berth Usage and Fatigue in the Trucking Industry." p. 23-31, 1998.	Study not available: could not be retrieved
Neale, V. L., T. A. Dingus, S. A. Garness, A. S. Keisler, and R. J. Carroll. "The Relationship between Truck Driver Sleeper Berth Sleep Quality and Safety-Related Critical Events." p. 65-78, 2002.	Study not available: could not be retrieved
Neri, D. F., R. L. Oyung, L. M. Colletti, M. M. Mallis, P. Y. Tam, and D. F. Dinges. "Controlled Breaks as a Fatigue Countermeasure on the Flight Deck." Aviation, space, and environmental medicine 73, no. 7 (2002). http://www.mrw.interscience.wiley.com/cochrane/clcentral/articles/230/CN-	Does not address the Key Question

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Neville, Kelly J., Roger U. Bisson, Jonathan French, and Patricia A. Boll. "Subjective Fatigue of C-141 Aircrews During Operation Desert Storm." Human Factors 36, no. 2 (1994): 339-349.	Not a population of interest
Nicholson, A. N. "Sleep and Wakefulness of the Airline Pilot." Log 47, no. 3 (1986): p. 6-7.	Study not available: could not be retrieved
Nicholson, A. N. "Duty Hours and Sleep Patterns in Air Crew Operating World-Wide Routes." Aerospace Medicine 43, (1972): 138-141.	Study not available: could not be retrieved
Nicholson, A. N. "Sleep Patterns of an Airline Pilot Operating World-Wide East-West Routes." Aerosp Med 41, no. 6 (1970): 626-32.	Insufficient number of participants or records
Nicholson, Anthony N., Peta A. Pascoe, Michael B. Spencer, and Barbara M. Stone. "Nocturnal Sleep and Daytime Alertness of Aircrew after Transmeridian Flights." Aviation, Space, and Environmental Medicine 57, no. 12, Sect II (1986): 43-52.	Does not address the Key Question
O'Neill, T. R., G. P. Krueger, and S. B. Van Hemel. Effects of Operating Practices on Commercial Driver Driver Alertness. Washington, D.C.: Federal Highway Administration, 1999, FHWA-MC-99-140.	Does not address the Key Question
Pack, A. I., G. Maislin, B. Staley, F. M. Pack, W. C. Rogers, C. F. P. George, and D. F. Dinges. "Impaired Performance in Commercial Drivers: Role of Sleep Apnea and Short Sleep Duration." American Journal of Respiratory & Critical Care Medicine 174, no. 4 (2006): 446-454.	Does not address the Key Question
Papadakaki, M., T. Kontogiannis, G. Tzamalouka, C. Darviri, and J. Chliaoutakis. "Exploring the Effects of Lifestyle, Sleep Factors and Driving Behaviors on Sleep-Related Road Risk: A Study of Greek Drivers." Accident Analysis and Prevention 40, no. 6 (2008): 2029-2036.	Not a population of interest
Petrie, K. J., D. Powell, and E. Broadbent. "Fatigue Self-Management Strategies and Reported Fatigue in International Pilots." Ergonomics 47, no. 5 (2004): 461-8.	Does not address the Key Question
Petrie, Keith J., and Alexander G. Dawson. "Symptoms of Fatigue and Coping Strategies in International Pilots." International Journal of Aviation Psychology 7, no. 3 (1997): 251-258.	Does not address the Key Question
Petrilli, Renée M., Gregory D. Roach, Drew Dawson, and Nicole Lamond. "The Sleep, Subjective Fatigue, and Sustained Attention of Commercial Airline Pilots During an International Pattern." Chronobiology International 23, no. 6 (2006): 1347-1362.	Does not address the Key Question
Philip, P., I. Ghorayeb, R. Stoohs, and J. C. Menny. "Determinants of Sleepiness in Automobile Drivers." Journal of Psychosomatic Research 41, no. 3 (1996): 279-288.	Not a population of interest
Philip, P., J. Taillard, C. Guilleminault, M. A. Quera Salva, B. Bioulac, and M. Ohayon. "Long Distance Driving and Self-Induced Sleep Deprivation among Automobile Drivers." Sleep 22, no. 4 (1999): 475-80.	Not a population of interest
Philip, P., J. Taillard, N. Moore, S. Delord, C. Valtat, P. Sagaspe, and B. Bioulac. "The Effects of Coffee and Napping on Nighttime Highway Driving: A Randomized Trial." Annals of Internal Medicine 144, no. 11 (2006): 785.	Study not available: could not be retrieved
Philip, P., P. Sagaspe, J. Taillard, N. Moore, C. Guilleminault, M. Sanchez-Ortuno, T. Akerstedt, and B. Bioulac. "Fatigue, Sleep Restriction, and Performance in Automobile Drivers: A Controlled Study in a Natural Environment." Sleep 26, no. 3 (2003). http://www.mrw.interscience.wiley.com/cochrane/clcentral/articles/493/CN-00437493/frame.html.	Not a population of interest
Philip, P., P. Sagaspe, N. Moore, J. Taillard, A. Charles, C. Guilleminault, and B. Bioulac. "Fatigue, Sleep Restriction and Driving Performance." Accident Analysis & Prevention 37, no. 3 (2005): p. 473-478.	Not a population of interest
Philip, P., P. Sagaspe, N. Moore, J. Taillard, A. Charles, C. Guilleminault, and B. Bioulac. "Fatigue,	Duplicate record

Reference	Reason for Exclusion
Sleep Restriction and Driving Performance." Accident Analysis & Prevention 37, no. 3 (2005): p. 473-478.	
Philip, Pierre, and Torbjorn Akerstedt. "Transport and Industrial Safety, How Are They Affected by Sleepiness and Sleep Restriction?" Sleep Medicine Reviews 10, no. 5 (2006): pp 347-356.	Not a population of interest
Ranney, T. A., L. A. Simmons, Z. Boulos, and M. M. Macchi. "Effect of an Afternoon Nap on Nighttime Performance in a Driving Simulator." Transportation Research Record, no. 1686 (1999): p. 49-56.	Fewer than 10 participants
Rash, Clarence E., and Sharon D. Manning. "Rest in Place." AeroSafety world 4, (2009): p. 38-42 : ill.	Not a full study report
Raymond W. Matthews, Sally A. Ferguson, Xuan Zhou, Anastasi Kosmadopoulos, David J. Kennawayb, Gregory D. Roach. "The Influence of Circadian Time and Sleep Dose on Subjective Fatigue Ratings." Accident Analysis & Prevention Volume 45, no. March 2012 (2011): Pages 55–61.	Not a population of interest
Raymond W. Matthews, Sally A. Ferguson, Xuan Zhou, Anastasi Kosmadopoulos, David J. Kennawayb, Gregory D. Roach. "Simulated Driving under the Influence of Extended Wake, Time of Day and Sleep Restriction." Accident Analysis & Prevention Volume 45, (2011): Pages 55–61.	Not a population of interest
Roach, G. D., D. Darwent, T. L. Shetten, and D. Dawson. "Long-Haul Pilots Use in-Flight Napping as a Countermeasure to Fatigue." Applied Ergonomics 42, no. 2 (2011): 214-218.	Does not address the Key Question
Rosekind, M.R., E. L. Co, K. B. Gregory, and D. L. Miller. Crew Factors in Flight Operations Xiii: A Survey of Fatigue Factors in Corporate/Executive Aviation Operations. Moffett Field, CA: NASA Ames Research Center, 2001.	Not a population of interest
Rosekind, M.R., R. C Graeber, D. F. dinges, L. J. Connell, M. S. Rountree, C. L. Spinweber, and K. A. Gillen. Crew Factors in Flight Operations Ix: Effects of Planned Cockpit Rest on Crew Performance and Alertness in Long-Haul Operations. Moffett Field, CA: NASA Technical Memorandum no. 108839, 1994.	Study not available: could not be retrieved
Sando, T., E. Mtoi, and R. Moses. "Potential Causes of Driver Fatigue: A Study on Transit Bus Operators in Florida " Transportation Research Board, (2010 (submitted)).	Does not address the Key Question
Santos, Eduardo H. R., Marco Tulio de Mello, Marcia Pradella-Hallinan, Ligia Luchesi, Maria Laura Nogueira Pires, and Sergio Tufik. "Sleep and Sleepiness among Brazilian Shift-Working Bus Drivers." Chronobiology International 21, no. 6 (2004): 881-888.	Does not address the Key Question
Sluiter, J. K., E. M. de Croon, T. F. Meijman, and M. H. W. Frings-Dresen. "Need for Recovery from Work Related Fatigue and Its Role in the Development and Prediction of Subjective Health Complaints." Occup Environ Med, (2003): i62-i70.	Does not address the Key Question
Sluiter, JK, Van Der Beek, AN, Frings-Dresen, MHW. "The Influence of Work Characteristics on the Need for Recovery and Experienced Health: A Study on Coach Drivers." Ergonomics Volume 42, no. Issue 4 (1999): p. 573-83.	Study not available: could not be retrieved
Smiley, A., D. B. Boivin, R. Heslegrave, and D. Davis. Investigation of Commercial Motor Vehicle Driver Cumulative Fatigue Recovery Periods: Literature Review. Montreal, Quebec, Canada: Transportation Development Centre, 2003.	Not a full study report
Sonnentag, Sabine; Zijlstra, Fred R. H. "Job Characteristics and Off-Job Activities as Predictors of Need for Recovery, Well-Being, and Fatigue." Journal of Applied Psychology Volume 91, no. March 2006 (2006): p330-350.	Not a population of interest
Spencer, M. B. "The Influence of Irregularity of Rest and Activity on Performance." Ergonomics 30, no. 9 (1987): 1275-1286.	Study not available: could not be retrieved
Stewart, S., and R. Abboud. "Flight Crew Scheduling, Performance, and Fatigue in a Uk Airline --	Does not address the Key Question

Reference	Reason for Exclusion
Phase 1." In International Conference on Fatigue Management in Transportation Operations. Seattle, WA, 2005.	
Stewart, S., and R. Abboud. "Flight Crew Scheduling, Performance, and Fatigue in a Uk Airline -- Phase 2." In International Conference on Fatigue Management in Transportation Operations. Seattle, WA, 2005.	Does not address the Key Question
Stress and Fatigue Effects of Driving Longer-Combination Vehicles. U.S. Department of Transportation, Federal Highway Administration, 2000, FMCSA-MCRT-00-012.	Does not address the Key Question
Sullivan, J. J. . "Fighting Fatigue." Public Roads Volume 67, no. Issue 2 (2003): 18.	Not a full study report
Suzuki, H., K. Moriguchi, M. Matsuura, T. Kojima, T. Matsuda, Y. Noda, H. Minemura, H. Yamamoto, T. Akashiba, and T. Horie. "Two Nap Sleep Test: An Easy Objective Sleepiness Test." Psychiatry Clin Neurosci 54, no. 3 (2000): 285-6.	Does not address the Key Question
Swaen, G. M. H., L. G. P. M. van Amelsvoort, U. Bültmann, and I. J. Kant. "Fatigue as a Risk Factor for Being Injured in an Occupational Accident: Results from the Maastricht Cohort Study." Occup Environ Med, (2003): i88-i92.	Not a population of interest
Thomas, G. R., T. G. Raslear, and G. I. Kuehn. The Effects of Work Schedule on Train Handling Performance and Sleep of Locomotive Engineers: A Simulator Study. Washington, D.C.: Federal Railroad Administration, 1997, Report DOT/FRA/ORD-97-09.	Does not address the Key Question
Ting, Ping-Huang and Hwang, Jiun-Ren and Doong, Ji-Liang and Jeng, Ming-Chang. "Driver Fatigue and Highway Driving: A Simulator Study " Physiology & Behavior Volume 94, no. Issue 3 (2008): pp. 448 - 453.	Not a population of interest
Trucking Research Institute. Commercial Motor Vehicle Driver Fatigue and Alertness Study Executive Summary. 1996.	Study not available: could not be retrieved
Tucker, P., S. Folkard, and I. McDonald. "Rest Breaks and Accident Risk." Lancet 361, no. 9358 (2003): 680.	Not a population of interest
Van Dongen, H. P. A., and G. Belenky. Investigation into Motor Carrier Practices to Achieve Optimal Commercial Motor Vehicle Driver Performance: Phase I. Washington, D.C.: Federal Motor Carrier Safety Administration, 2010, FMCSA-RRR-10-005.	Does not address the Key Question
Van Dongen, H. P. A., M. L. Jackson, and G. Belenky. Duration of Restart Period Needed to Recycle with Optimal Performance Phase Ii. 2010, FMCSA-MC-RRR-10-062.	Study not available: could not be retrieved
Vespa, S, Wylie, D and T. Shultz. "Study of Commercial Vehicle Drivers' Rest Periods and Recovery of Performance in an Operational Environment." Elsevier (1998). http://trid.trb.org/view/1998/C/543011.	Study not available: could not be retrieved
Waterhouse, Jim, Thomas Reilly, Greg Atkinson, and Ben Edwards. "Jet Lag: Trends and Coping Strategies." The Lancet 369, no. 9567 (2007): 1117-1129.	Not a full study report
Weatherley, B. "Stop before You Drop Off." COMMERCIAL MOTOR 188, no. 4792 (1998): p. 14.	Study not available: could not be retrieved
Wegmann, Hans M., Alexander Gundel, Martin Naumann, and Alexander Samel. "Sleep, Sleepiness, and Circadian Rhythmicity in Aircrews Operating on Transatlantic Routes." Aviation, Space, and Environmental Medicine 57, no. 12, Sect II (1986): 53-64.	Does not address the Key Question
Williamson, A. M., A. M. Feyer, and R. Friswell. "The Impact of Work Practices on Fatigue in Long Distance Truck Drivers." Accident Analysis & Prevention 28, no. 6 (1996): 709-719.	Does not address the Key Question
Williamson, A., A. M. Feyer, R. Friswell, and S. Finlay-Brown. Demonstration Project for Fatigue Management Programs in the Road Transport Industry: Summary of Findings. Australian Transport Safety Bureau, 2000, 0-642-25591-1.	Does not address the Key Question

Reference	Reason for Exclusion
Williamson, A., A. M. Feyer, R. Friswell, and S. Finlay-Brown. On-Road Evaluations of a Regulated Hours Regime and an Alternative Compliance Regime. Australian Transport Safety Bureau, 2000, 0642255792.	Does not address the Key Question
Wilner, Frank N. "No Parking, No Rest." Traffic World, (1999): 17.	Not a full study report
Wislocki, John. "To Sleep, Perchance to Dream." Transport Topics, (2000).	Study not available: could not be retrieved
Wright, Bruce A., and Rodger J. Koppa. "The Circadian Variability of Human Performance in the Military Air Combat Environment." Human Performance in Extreme Environments 4, no. 1 (1999): 21-26.	Study not available: could not be retrieved
Wright, Kenneth P., Jr. "Modeling the Effectiveness of Naps as a Countermeasure to Driver Sleepiness and Accidents." Sleep: Journal of Sleep and Sleep Disorders Research 27, no. 8 (2004): 1446-1448.	Not a full study report
Wright, N., and A. McGown. "Vigilance on the Civil Flight Deck: Incidence of Sleepiness and Sleep During Long-Haul Flights and Associated Changes in Physiological Parameters." Ergonomics 44, no. 1 (2001): 82-106.	Does not address the Key Question
Wu, Lora, and Gregory Belenky. "Effects of Scheduling on Sleep and Performance in Commercial Motorcoach Operations." In PROCEEDINGS of the Sixth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, pp 59-65, 2011.	Not a full study report
Wulfeck, W. H. "Fatigue and Hours of Service of Interstate Truck Drivers. Ii. Psychomotor Reactions." Public Health Bulletin. Washington 265, (1941): 135-177.	Study not available: could not be retrieved
Wylie, C. D. Commercial Motor Vehicles Driver Fatigue, Alertness, and Countermeasures Survey. Goleta, CA: Essex Corp, 1997.	Study not available: could not be retrieved
Wylie, C. D., T. Shultz, J. C. Miller, and M. M. Mitler. Commercial Motor Vehicle Driver Rest Periods and Recovery of Performance. Montreal, Quebec, Canada: Transportation Development Centre, 1997, TP 12850E.	Insufficient number of participants or records
Wylie, C. D., T. Shultz, J. C. Miller, M. M. Mitler, and R. R. Mackie. Commercial Motor Vehicle Driver Fatigue and Alertness Study: Project Report. 1996.	Study not available: could not be retrieved
Yee, A. J., and P. Philip. "Effects of Coffee and Napping on Nighttime Highway Driving... Philip P, Taillard J, Moore N Et Al. The Effects of Coffee and Napping on Nighttime Highway Driving: A Randomized Trial. Ann Intern Med. 2006;144:785-91." Annals of Internal Medicine 146, no. 3 (2007): 229-229.	Not a full study report

Table D-4. Excluded studies (Key Question 3A)

Reference	Reason for Exclusion
Adams-Guppy, J. and A. Guppy, Truck driver fatigue risk assessment and management: a multinational survey. Ergonomics, 2003. 46(8): p. 763-79.	Not conducted in the U.S.
Anderson, D.G., Workplace violence in long haul trucking: occupational health nursing update. AAOHN J, 2004. 52(1): p. 23-7.	Data could not be extracted.
Belzer, M.H., D. Rodriguez, and S.A. Sedo, Paying for safety: An economic analysis of the effect of compensation on truck driver safety, F.M.C.S. Administration, Editor. 2002.	Does not address key question.
Bishop, R., et al., Distracted driving countermeasures for commercial vehicles: A synthesis of safety practice. 2011.	Does not address key question.
Blower, D., P.E. Green, and A. Matteson, Bus operator types and driver factors in fatal bus	Does not address key question.

Reference	Reason for Exclusion
crashes: results from the buses involved in fatal accidents survey. 2008, FMCSA.	
Bunn, T.L., et al., The effects of semi-truck driver age and gender and the presence of passengers on collisions with other vehicles. Traffic Inj Prev, 2009. 10(3): p. 266-72.	Data restricted to drivers in crashes.
Cunradi, C.B., et al., Burnout and alcohol problems among urban transit operators in San Francisco. Addict Behav, 2003. 28(1): p. 91-109.	Railway workers.
Dinges, D.F., et al., Pilot test of fatigue management technologies. 2005.	Article enrolls fewer than 50 subjects.
French, S.A., Harnack, L.J., Toomey, T.L., Hannan, P.J. Association between body weight, physical activity and food choices among metropolitan transit workers. Int J Behav Nutr Phys Act. 2007 Nov 2;4:52. PubMed PMID: 17980026; PubMed Central PMCID: PMC2200661.	Data is inclusive of non-driving workers.
Global Insight, The U.S. Truck Driver Shortage: Analysis and Forecasts. 2005.	Not a study.
Grenzeback, L.R., S. Lin, and J. Meunier, Operational differences and similarities among the motorcoach, school bus, and trucking industries. 2005	Not a study.
Krueger, G.P. Research on the Health and Wellness of Commercial Truck and Bus Drivers: Summary of an International Conference. 2012: Transportation Research Board.	Does not address key question.
Lewis, C.A., and Johnson, P.W. Whole-body vibration exposure in metropolitan bus drivers. Occup Med (Lond). 2012 Oct;62(7):519-24. doi: 10.1093/occmed/kqs096. Epub 2012 Jul 9. PubMed PMID: 22778239.	Only 13 participants.
Lichtenstein, B., et al., HIV risk among long-haul truckers in the USA. Cult Health Sex, 2008. 10(1): p. 43-56.	Article enrolls fewer than 50 subjects.
Lipton, R., C. Cunradi, and M.J. Chen, Smoking and all-cause mortality among a cohort of urban transit operators. J Urban Health, 2008. 85(5): p. 759-65.	Bus driver data can't be isolated from railway, trolley driver data.
Manila/ECRI, Evidence Report: Cardiovascular Disease and Commercial Motor Vehicle Driver Safety (Expedited Review). 2007. p. 517p.	Does not address key question.
Manila/ECRI, Evidence Report: Obstructive Sleep Apnea and Commercial Motor Vehicle Driver Safety (Comprehensive Review), Volume I. 2007. p. 388p.	Does not address key question.
McCall, B.P. and I.B. Horwitz, Occupational vehicular accident claims: a workers' compensation analysis of Oregon truck drivers 1990-1997. Accid Anal Prev, 2005. 37(4): p. 767-74.	Data restricted to drivers injured in crashes.
McCree, D.H., et al., Sexual and drug use risk behaviors of long-haul truck drivers and their commercial sex contacts in New Mexico. Public Health Rep, 2010. 125(1): p. 52-60.	Article enrolls fewer than 50 subjects.
Mehling, W.E. and Krause, N. Are difficulties perceiving and expressing emotions associated with low-back pain? The relationship between lack of emotional awareness (alexithymia) and 12-month prevalence of low-back pain in 1180 urban public transit operators. J Psychosom Res. 2005 Jan;58(1):73-81.	Article does not differentiate bus drivers from drivers of trolley buses, light rail streetcars, and historic cable cars.
Olson, R., et al., A new health promotion model for lone workers: results of the Safety & Health Involvement For Truckers (SHIFT) pilot study. J Occup Environ Med, 2009. 51(11): p. 1233-46.	Demographic and health data skewed because sample included only overweight/obese.
Reston, J.T., et al., Evidence report: Parkinson's disease, multiple sclerosis, and commercial motor vehicle driver safety (comprehensive review). 2009. p. 165p.	Does not address key question.
Sando, T., Angel, M., Mtoi, E., and Moses, R. Analysis of the relationship between operator cumulative driving hours and involvement in preventable collisions. Transportation Research Board. 2010.	Part of a final report that is already included in this evidence review; data not address key question.

Reference	Reason for Exclusion
Sando, T., Moses, R., Angel, M., Mtoi, E., and Wiley, V. Safety implications of transit operator schedule politices. Florida Department of Transportation Transit Office. 2010. Oct.	Data does not address key question.
Sando, T., Mtoi, E., and Moses, R. Potential causes of driver fatigue: A study on transit bus operators in Florida. Transportation Research Board. 2010. Nov.	Part of a final report that is already included in this evidence review; data does not address key question.
Stasko, J.C. and A.V. Neale, Health care risks and access within the community of Michigan over-the-road truckers. Work, 2007. 29(3): p. 205-11.	Article enrolls fewer than 50 subjects.
Transportation Research Board of the National Academies, Motorcoach Industry Hours of Service and Fatigue Management Techniques: A Synthesis of Safety Practice. 2005. Washington, D.C.	Data surveyed motorcoach company representatives and managers.

Table D-2. Excluded studies (Key Question 3B)

Reference	Reason for Exclusion
Anderson, D. and P. Riley, Determining standards of care for substance abuse and alcohol use in long-haul truck drivers. Nurs Clin North Am, 2008. 43(3): p. 357-65, viii.	Does not address key question.
Brock, J.F., et al., Motorcoach industry hours of service and fatigue management techniques, in Commercial Truck and Bus Safety. 2005, FMCSA.	Low number of respondents, and the report does not identify the total number of respondents; surveys of focus groups in 1999 used to fill gap for low response rate.
Bunn, T.L., et al., Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries. Accid Anal Prev, 2005. 37(5): p. 862-9.	Does not address key question.
Collet, C., et al., Assessing workload through physiological measurements in bus drivers using an automated system during docking. Hum Factors, 2003. 45(4): p. 539-48.	Does not address key question.
French, S.A., Harnack, LJ, Toomey, T.L., and Hannan, P.J. Association between body weight, physical activity and food choices among metropolitan transit workers. Int J Behav Nutr Phys Act. 2007 Nov 2;4:52. PubMed PMID: 17980026; PubMed Central PMCID: PMC2200661.	Data is inclusive of non-driving workers.
Hanowski, R.J., et al., Critical Incidents that Occur in the 10th and 11th Hour of Driving in Commercial Vehicle Operations: Does Risk Increase in the 11th Hour? 2007.	Does not address key question.
Hickman, J.S., R.J. Hanowski, and J. Bocanegra, Distraction in commercial trucks and buses: assessing prevalence and risk in conjunction with crashes and near-crashes. 2010.	Does not address key question.
Kashima, S.R., A petroleum company's experience in implementing a comprehensive medical fitness for duty program for professional truck drivers. J Occup Environ Med, 2003. 45(2): p. 185-96.	Does not address key question.
Krause, N., et al., Physical workload, ergonomic problems, and incidence of low back injury: a 7.5-year prospective study of San Francisco transit operators. Am J Ind Med, 2004. 46(6): p. 570-85.	Does not address key question.
Krueger, G.P. Research on the Health and Wellness of Commercial Truck and Bus Drivers: Summary of an International Conference. 2012: Transportation Research Board.	Does not address key question.
Lewis, C.A., and Johnson, P.W. Whole-body vibration exposure in metropolitan bus drivers. Occup Med (Lond). 2012 Oct;62(7):519-24. doi: 10.1093/occmed/kqs096. Epub 2012 Jul 9. PubMed PMID: 22778239.	Only 13 participants.
Manila/ECRI, Evidence Report: Cardiovascular Disease and Commercial Motor Vehicle Driver Safety (Expedited Review). 2007. p. 517p.	Does not address key question.

Reference	Reason for Exclusion
Manila/ECRI, Evidence Report: Obstructive Sleep Apnea and Commercial Motor Vehicle Driver Safety (Comprehensive Review), Volume I. 2007. p. 388p.	Does not address key question.
Okunribido, O.O., et al., City bus driving and low back pain: a study of the exposures to posture demands, manual materials handling and whole-body vibration. Appl Ergon, 2007. 38(1): p. 29-38.	Not conducted in the U.S.
Reston, J.T., et al., Evidence report: Parkinson's disease, multiple sclerosis, and commercial motor vehicle driver safety (comprehensive review). 2009. p. 165p.	Does not address key question.
Sando, T., Mtoi, E., and Moses, R. Potential causes of driver fatigue: A study on transit bus operators in Florida. Transportation Research Board. 2010. Nov.	Part of a final report that is already included in this evidence review.
Sando, T., Angel, M., Mtoi, E., and Moses, R. Analysis of the relationship between operator cumulative driving hours and involvement in preventable collisions. Transportation Research Board. 2010.	Part of a final report that is already included in this evidence review.
Spector, J.T., D. Adams, and B. Silverstein, Burden of work-related knee disorders in Washington State, 1999 to 2007. J Occup Environ Med, 2011. 53(5): p. 537-47.	Data could not be extracted.
Spielholz, P., et al., Assessment of perceived injury risks and priorities among truck drivers and trucking companies in Washington State. J Safety Res, 2008. 39(6): p. 569-76.	Data could not be extracted from larger study population.
Transportation Research Board of the National Academies, Motorcoach Industry Hours of Service and Fatigue Management Techniques: A Synthesis of Safety Practice. 2005. Washington, D.C.	Data surveyed motorcoach company representatives and managers.
Waters, T., et al., The impact of operating heavy equipment vehicles on lower back disorders. Ergonomics, 2008. 51(5): p. 602-36.	Coach/long-haul truck drivers not included.

Table D-3. Excluded studies (Key Question 3C)

Reference	Reason for Exclusion
Anderson, D.G., Workplace violence in long haul trucking: occupational health nursing update. AAOHN J, 2004. 52(1): p. 23-7.	Data could not be extracted.
Blanco, M., et al., Investigating critical incidents, driver restart period, sleep quantity, and crash countermeasures in commercial vehicle operations using naturalistic data collection. 2011	Does not address key question.
Brock, J.F., et al., Motorcoach industry hours of service and fatigue management techniques, in Commercial Truck and Bus Safety. 2005, FMCSA.	Low number of respondents, and the report does not identify the total number of respondents; surveys of focus groups in 1999 used to fill gap for low response rate.
Bunn, T.L., et al., Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries. Accid Anal Prev, 2005. 37(5): p. 862-9.	Does not address key question.
Davis, M.E., et al., Modeling particle exposure in U.S. trucking terminals. Environ Sci Technol, 2006. 40(13): p. 4226-32.	Does not model driver exposure.
de Croon, E.M., J.K. Sluiter, and M.H. Frings-Dresen, Need for recovery after work predicts sickness absence: a 2-year prospective cohort study in truck drivers. J Psychosom Res, 2003. 55(4): p. 331-9.	Not conducted in the U.S.
French, S.A., Harnack, LJ, Toomey, T.L., and Hannan, P.J. Association between body weight, physical activity and food choices among metropolitan transit workers. Int J Behav Nutr Phys Act. 2007 Nov 2;4:52. PubMed PMID: 17980026; PubMed Central PMCID: PMC2200661.	Data is inclusive of non-driving workers.
Garshick, E., et al., Lung cancer and vehicle exhaust in trucking industry workers. Environ Health	Does not address key question.

Reference	Reason for Exclusion
Perspect, 2008. 116(10): p. 1327-32	
Garshick, E., T.J. Smith, and F. Laden, Quantitative assessment of lung cancer risk from diesel exhaust exposure in the US trucking industry: a feasibility study. Health Effects Institute, 2002: p. 115-150.	Does not address key question.
Glaso, L., et al., Bus drivers' exposure to bullying at work: an occupation-specific approach. Scand J Psychol, 2011. 52(5): p. 484-93.	Not conducted in the U.S.
Grenzeback, L.R., S. Lin, and J. Meunier, Operational differences and similarities among the motorcoach, school bus, and trucking industries. 2005.	Not a study.
Jovanis, P.P., K.-F. Wu, and C. Chen, Hours of service and driver fatigue: driver characteristics research, FMCSA, Editor. 2011. p. 88.	Does not address key question.
Krause, N., et al., Physical workload, ergonomic problems, and incidence of low back injury: a 7.5-year prospective study of San Francisco transit operators. Am J Ind Med, 2004. 46(6): p. 570-85.	Does not address key question.
Lewis, C.A., and Johnson, P.W. Whole-body vibration exposure in metropolitan bus drivers. Occup Med (Lond). 2012 Oct;62(7):519-24. doi: 10.1093/occmed/kqs096. Epub 2012 Jul 9. PubMed PMID: 22778239.	Only 13 participants.
Lofgren, D.J., Occupational carbon monoxide violations in the State of Washington, 1994-1999. Appl Occup Environ Hyg, 2002. 17(7): p. 501-11.	Does not address key question.
Lyons, J., Factors contributing to low back pain among professional drivers: a review of current literature and possible ergonomic controls. Work, 2002. 19(1): p. 95-102.	Not a study.
Park, S.-W., et al., Safety Implications of Multi-day Driving Schedules for Truck Drivers: Comparison of Field Experiments and Crash Data Analysis. 2005.	Does not address key question.
Reeb-Whitaker, C.K., et al., Occupational carbon monoxide poisoning in Washington State, 2000-2005. J Occup Environ Hyg, 2010. 7(10): p. 547-56.	Driver data can't be isolated from larger study population.
Rugulies, R. and N. Krause, Effort-reward imbalance and incidence of low back and neck injuries in San Francisco transit operators. Occup Environ Med, 2008. 65(8): p. 525-33.	Bus driver data can't be isolated from railway, trolley driver data.
Sando, T., Mtoi, E., and Moses, R. Potential causes of driver fatigue: A study on transit bus operators in Florida. Transportation Research Board. 2010. Nov.	Part of a final report that is already included in this evidence review.
Sando, T., Angel, M., Mtoi, E., and Moses, R. Analysis of the relationship between operator cumulative driving hours and involvement in preventable collisions. Transportation Research Board. 2010.	Part of a final report that is already included in this evidence review.
Shattell, M., et al., Occupational stressors and the mental health of truckers. Issues Ment Health Nurs, 2010. 31(9): p. 561-8.	Data skewed – sample recruited for their "illegal or illicit behaviors."
Sheesley, R.J., et al., Tracking personal exposure to particulate diesel exhaust in a diesel freight terminal using organic tracer analysis. J Expo Sci Environ Epidemiol, 2009. 19(2): p. 172-86.	Sample too small.
Spielholz, P., et al., Assessment of perceived injury risks and priorities among truck drivers and trucking companies in Washington State. J Safety Res, 2008. 39(6): p. 569-76.	Driver data can't be isolated from larger study population.
Sonntag, D.B., Gao, H.O., and Holmén, B.A. Variability of particle number emissions from diesel and hybrid diesel-electric buses in real driving conditions. Environ Sci Technol. 2008 Aug 1;42(15):5637-43. PubMed PMID: 18754487.	Does not apply to key question.
Taylor, A.H. and L. Dorn, Stress, fatigue, health, and risk of road traffic accidents among professional drivers: the contribution of physical inactivity. Annu Rev Public Health, 2006. 27: p. 371-91.	Not conducted in the U.S.

Reference	Reason for Exclusion
Waters, T., et al., The impact of operating heavy equipment vehicles on lower back disorders. Ergonomics, 2008. 51(5): p. 602-36.	Coach/long-haul truck drivers not included.
Whitfield Jacobson, P.J., A.D. Prawitz, and J.M. Lukaszuk, Long-haul truck drivers want healthful meal options at truck-stop restaurants. J Am Diet Assoc, 2007. 107(12): p. 2125-9.	Does not address key question.

Table D-4. Excluded studies (Key Question 3D)

Reference	Reason for Exclusion
Ancoli-Israel, S., et al., Expert Panel Recommendations: Obstructive sleep apnea and commercial motor vehicle driver safety 2008.	Does not address key question.
Anderson, D.G., Workplace violence in long haul trucking: occupational health nursing update. AAOHN J, 2004. 52(1): p. 23-7.	Data could not be extracted.
Apostolopoulos, Y., et al., Worksite-induced morbidities among truck drivers in the United States. AAOHN J, 2010. 58(7): p. 285-96.	Does not address key question.
Apostolopoulos, Y., et al., Cruising for truckers on highways and the internet: sexual networks and infection risk. AIDS Educ Prev, 2011. 23(3): p. 249-66.	Does not address key question.
Bunn, W.B., 3rd, et al., A reevaluation of the literature regarding the health assessment of diesel engine exhaust. Inhal Toxicol, 2004. 16(14): p. 889-900.	Not a study.
Chiu, Y.H., et al., Secondhand smoke exposure and inflammatory markers in nonsmokers in the trucking industry. Environ Health Perspect, 2011. 119(9): p. 1294-300.	Does not address key question.
Chung, Y.S. and J.T. Wong, Developing effective professional bus driver health programs: an investigation of self-rated health. Accid Anal Prev, 2011. 43(6): p. 2093-103.	Not conducted in the U.S.
Cohen, Y., et al., Relationship between night myopia and night-time motor vehicle accidents. Acta Ophthalmol Scand, 2007. 85(4): p. 367-70.	Not conducted in the U.S.
Dagan, Y., et al., Body Mass Index (BMI) as a first-line screening criterion for detection of excessive daytime sleepiness among professional drivers. Traffic Inj Prev, 2006. 7(1): p. 44-8.	Not conducted in the U.S.
de Croon, E.M., J.K. Sluiter, and M.H. Frings-Dresen, Need for recovery after work predicts sickness absence: a 2-year prospective cohort study in truck drivers. J Psychosom Res, 2003. 55(4): p. 331-9.	Not conducted in the U.S.
French, S.A., Harnack, LJ, Toomey, T.L., and Hannan, P.J. Association between body weight, physical activity and food choices among metropolitan transit workers. Int J Behav Nutr Phys Act. 2007 Nov 2;4:52. PubMed PMID: 17980026; PubMed Central PMCID: PMC2200661.	Data is inclusive of non-driving workers.
French, S.A., et al., Worksite environment intervention to prevent obesity among metropolitan transit workers. Prev Med, 2010. 50(4): p. 180-5.	Does not address key question.
Gurubhagavatula, I., et al., Estimated cost of crashes in commercial drivers supports screening and treatment of obstructive sleep apnea. Accid Anal Prev, 2008. 40(1): p. 104-15.	Does not address key question.
Harshman, R.S., et al., Impact of a hypertension management/health promotion program on commercial driver's license employees of a self-insured utility company. J Occup Environ Med, 2008. 50(3): p. 359-65.	Subjects not long-haul drivers.
Hwang, G.S., et al., Effects of a tailored health promotion program to reduce cardiovascular disease risk factors among middle-aged and advanced-age bus drivers. Asia Pac J Public Health, 2012. 24(1): p. 117-27.	Not conducted in U.S.

Reference	Reason for Exclusion
Krause, N., et al., Physical workload, ergonomic problems, and incidence of low back injury: a 7.5-year prospective study of San Francisco transit operators. Am J Ind Med, 2004. 46(6): p. 570-85.	Does not address key question.
Krueger, G.P. Research on the Health and Wellness of Commercial Truck and Bus Drivers: Summary of an International Conference. 2012: Transportation Research Board.	Does not address key question.
Krueger, G.P., et al., Health and Wellness of Commercial Drivers. Transportation Research E-Circular, 2007(E-C117): p. pp 58-91.	Not a study.
Leigh, J.P., et al., Costs of occupational injury and illness across industries. Scand J Work Environ Health, 2004. 30(3): p. 199-205.	Does not address key question.
Lewis CA, Johnson PW. Whole-body vibration exposure in metropolitan bus drivers. Occup Med (Lond). 2012 Oct;62(7):519-24. doi: 10.1093/occmed/kqs096. Epub 2012 Jul 9. PubMed PMID: 22778239.	Only 13 participants.
Lichtenstein, B., et al., HIV risk among long-haul truckers in the USA. Cult Health Sex, 2008. 10(1): p. 43-56.	Does not address key question.
Lipton, R., C. Cunradi, and M.J. Chen, Smoking and all-cause mortality among a cohort of urban transit operators. J Urban Health, 2008. 85(5): p. 759-65.	Bus driver data can't be isolated from railway, trolley driver data.
Lofgren, D.J., Occupational carbon monoxide violations in the State of Washington, 1994-1999. Appl Occup Environ Hyg, 2002. 17(7): p. 501-11.	Does not address key question.
Lyons, J., Factors contributing to low back pain among professional drivers: a review of current literature and possible ergonomic controls. Work, 2002. 19(1): p. 95-102.	Not a study.
Manila/ECRI, Evidence Report: Cardiovascular Disease and Commercial Motor Vehicle Driver Safety (Expedited Review). 2007. p. 517p.	Does not address key question.
Manila/ECRI, Evidence Report: Obstructive Sleep Apnea and Commercial Motor Vehicle Driver Safety (Comprehensive Review), Volume I. 2007. p. 388p.	Does not address key question.
McCree, D.H., et al., Sexual and drug use risk behaviors of long-haul truck drivers and their commercial sex contacts in New Mexico. Public Health Rep, 2010. 125(1): p. 52-60.	Does not address key question.
Okunribido, O.O., et al., City bus driving and low back pain: a study of the exposures to posture demands, manual materials handling and whole-body vibration. Appl Ergon, 2007. 38(1): p. 29-38.	Not conducted in U.S.
Olson, R., et al., A new health promotion model for lone workers: results of the Safety & Health Involvement For Truckers (SHIFT) pilot study. J Occup Environ Med, 2009. 51(11): p. 1233-46.	Demographic and health data skewed because sample included only overweight/obese.
Pack, A.I., et al., Impaired performance in commercial drivers: role of sleep apnea and short sleep duration. Am J Respir Crit Care Med, 2006. 174(4): p. 446-54.	Data set all suspected at outset of having OSA.
Parks, P., et al., Screening for obstructive sleep apnea during commercial driver medical examinations. J Occup Environ Med, 2009. 51(3): p. 275-82.	Does not distinguish between coach, truck drivers.
Reeb-Whitaker, C.K., et al., Occupational carbon monoxide poisoning in Washington State, 2000-2005. J Occup Environ Hyg, 2010. 7(10): p. 547-56.	Driver data can't be isolated from larger study population.
Sando, T., Mtoi, E., and Moses, R. Potential causes of driver fatigue: A study on transit bus operators in Florida. Transportation Research Board. 2010. Nov.	Part of a final report that is already included in this evidence review.
Sando, T., Angel, M., Mtoi, E., and Moses, R. Analysis of the relationship between operator cumulative driving hours and involvement in preventable collisions. Transportation Research Board. 2010. Nov.	Part of a final report that is already included in this evidence review.

Reference	Reason for Exclusion
Sando, T., Moses, R., Angel, M., Mtoi, E., and Wiley, V. Safety implications of transit operator schedule politices. Florida Department of Transportation Transit Office. 2010. Oct.	Data does not address key question.
Rugulies, R. and N. Krause, Effort-reward imbalance and incidence of low back and neck injuries in San Francisco transit operators. Occup Environ Med, 2008. 65(8): p. 525-33.	Bus driver data can't be isolated from railway, trolley driver data.
Shattell, M., et al., Occupational stressors and the mental health of truckers. Issues Ment Health Nurs, 2010. 31(9): p. 561-8.	Data skewed – sample recruited for their "illegal or illicit behaviors."
Smith, T.J., et al., Overview of particulate exposures in the US trucking industry. J Environ Monit, 2006. 8(7): p. 711-20.	Does not address key question.
Sorensen, G., et al., Work experiences and tobacco use: findings from the gear up for health study. J Occup Environ Med, 2009. 51(1): p. 87-94.	Driver data can't be isolated from larger study population.
Sorensen, G., et al., Tobacco use cessation and weight management among motor freight workers: results of the gear up for health study. Cancer Causes Control, 2010. 21(12): p. 2113-22.	Driver data can't be isolated from larger study population.
Spector, J.T., D. Adams, and B. Silverstein, Burden of work-related knee disorders in Washington State, 1999 to 2007. J Occup Environ Med, 2011. 53(5): p. 537-47.	Data could not be extracted.
Spielholz, P., et al., Assessment of perceived injury risks and priorities among truck drivers and trucking companies in Washington State. J Safety Res, 2008. 39(6): p. 569-76.	Data could not be extracted from larger study population.
Talmage, J.B., et al., Consensus criteria for screening commercial drivers for obstructive sleep apnea: evidence of efficacy. J Occup Environ Med, 2008. 50(3): p. 324-9.	Does not address key question.
Transportation Research Board of the National Academies, Motorcoach Industry Hours of Service and Fatigue Management Techniques: A Synthesis of Safety Practice. 2005. Washington, D.C.	Data surveyed motorcoach company representatives and managers.
Tregear, S., et al., Obstructive sleep apnea and risk of motor vehicle crash: systematic review and meta-analysis. J Clin Sleep Med, 2009. 5(6): p. 573-81.	Does not address key question.
Tse, J.L.M., R. Flin, and K. Mearns, Bus driver well-being review: 50 years of research. 2006.	Not a study.
Waters, T., et al., The impact of operating heavy equipment vehicles on lower back disorders. Ergonomics, 2008. 51(5): p. 602-36.	Coach/long-haul truck drivers not included.

Table D-5. Excluded studies (Key Question 4)

Reference	Reason for Exclusion
Ahasan, R., et al., Adaptation to night shifts and synchronisation processes of night workers. J Physiol Anthropol Appl Human Sci, 2001. 20(4): p. 215-26.	Doesn't provide data on risk factors for acute fatigue.
Akerstedt, T., Psychological and psychophysiological effects of shift work. Scand J Work Environ Health, 1990. 16 Suppl 1: p. 67-73.	Inadequate referencing.
Banks, S. and D.F. Dinges, Behavioral and physiological consequences of sleep restriction. J Clin Sleep Med, 2007. 3(5): p. 519-28.	Doesn't provide data on risk factors for acute fatigue.
Belenky, G. and L.J. Wu, Literature review on fatigue and health issues associated with commercial motor vehicle driver hours of service: update from 2004. 2008.	Doesn't provide data on risk factors for acute fatigue.
Boivin, D.B., G.M. Tremblay, and F.O. James, Working on atypical schedules. Sleep Med, 2007. 8(6): p. 578-89.	Doesn't provide data on risk factors for acute fatigue.
Bonnet, M.H. and D.L. Arand, We are chronically sleep deprived. Sleep, 1995. 18(10): p. 908-11.	Not a review.

Reference	Reason for Exclusion
Brown, I.D., Driver fatigue. Hum Factors, 1994. 36(2): p. 298-314.	Inadequate referencing.
Caldwell, J.A., J.L. Caldwell, and R.M. Schmidt, Alertness management strategies for operational contexts. Sleep Med Rev, 2008. 12(4): p. 257-73.	Doesn't provide data on risk factors for acute fatigue.
Caldwell, J.A., Jr., Fatigue in the aviation environment: an overview of the causes and effects as well as recommended countermeasures. Aviat Space Environ Med, 1997. 68(10): p. 932-8.	Doesn't provide data on risk factors for acute fatigue.
Connor, J., et al., The role of driver sleepiness in car crashes: a systematic review of epidemiological studies. Accid Anal Prev, 2001. 33(1): p. 31-41.	Crash risk only.
Crum, M.R., P.C. Morrow, and C.W. Daecher, Motor carrier scheduling practices and their influence on driver fatigue. 2002. p. 230 p.	Doesn't provide study conclusions.
Dawson, D. and K. McCulloch, Managing fatigue: it's about sleep. Sleep Med Rev, 2005. 9(5): p. 365-80.	Doesn't provide data on risk factors for acute fatigue.
Dawson, D., et al., Modelling fatigue and the use of fatigue models in work settings. Accid Anal Prev, 2011. 43(2): p. 549-64.	Not a review.
FMCSA, Bus driver fatigue and stress issues (tech brief)[159]	Not a review.
Fletcher, A., et al., Countermeasures to driver fatigue: a review of public awareness campaigns and legal approaches. Aust N Z J Public Health, 2005. 29(5): p. 471-6.	Doesn't provide data on risk factors for acute fatigue.
Gander, P., et al., Fatigue risk management: Organizational factors at the regulatory and industry/company level. Accid Anal Prev, 2011. 43(2): p. 573-90.	Doesn't provide data on risk factors for acute fatigue.
Guilleminault, C. and S.N. Brooks, Excessive daytime sleepiness: a challenge for the practising neurologist. Brain, 2001. 124(Pt 8): p. 1482-91.	Inadequate referencing.
Harrington, J.M., Shift work and health--a critical review of the literature on working hours. Ann Acad Med Singapore, 1994. 23(5): p. 699-705.	Doesn't provide data on risk factors for acute fatigue.
Knauth, P., Extended work periods. Ind Health, 2007. 45(1): p. 125-36.	Doesn't provide data on risk factors for acute fatigue.
Lerman, S.E., et al., Fatigue risk management in the workplace. J Occup Environ Med, 2012. 54(2): p. 231-58.	Not a review.
Owens, J.A., Sleep loss and fatigue in healthcare professionals. J Perinat Neonatal Nurs, 2007. 21(2): p. 92-100; quiz 101-2.	Inadequate referencing.
Philip, P., Sleepiness of occupational drivers. Ind Health, 2005. 43(1): p. 30-3.	Doesn't provide data on risk factors for acute fatigue.
Pilcher, J.J., B.J. Lambert, and A.I. Huffcutt, Differential effects of permanent and rotating shifts on self-report sleep length: a meta-analytic review. Sleep, 2000. 23(2): p. 155-63.	Doesn't provide data on risk factors for acute fatigue.
Rosenthal, T.C., et al., Fatigue: an overview. Am Fam Physician, 2008. 78(10): p. 1173-9.	Doesn't provide data on risk factors for acute fatigue.
Sack, R.L., et al., Circadian rhythm sleep disorders: part I, basic principles, shift work and jet lag disorders. An American Academy of Sleep Medicine review. Sleep, 2007. 30(11): p. 1460-83.	Doesn't provide data on risk factors for acute fatigue.
Saito, K., Measurement of fatigue in industries. Ind Health, 1999. 37(2): p. 134-42.	Inadequate referencing.
Sando, T., E. Mtoi, and R. Moses, Potential causes of driver fatigue: a study on transit bus operators in Florida. 2010.	Inadequate referencing.

Reference	Reason for Exclusion
Sofianopoulos, S., B. Williams, and F. Archer, Paramedics and the effects of shift work on sleep: a literature review. Emerg Med J, 2012. 29(2): p. 152-5.	Limited to ambulance workers.
Spurgeon, A., J. Harrington, and C. Cooper, Health and safety problems associated with long working hours: a review of the current position. Occup Environ Med., 1997. 54: p. 367–375.	Doesn't provide data on risk factors for acute fatigue.
Taylor, A.H. and L. Dorn, Stress, fatigue, health, and risk of road traffic accidents among professional drivers: the contribution of physical inactivity. Annu Rev Public Health, 2006. 27: p. 371-91.	Doesn't provide data on risk factors for acute fatigue.
Tiesinga, L.J., T.W. Dassen, and R.J. Halfens, Fatigue: a summary of the definitions, dimensions, and indicators. Nurs Diagn, 1996. 7(2): p. 51-62.	Doesn't provide data on risk factors for acute fatigue.
Toth, L.A. and K. Jhaveri, Sleep mechanisms in health and disease. Comp Med, 2003. 53(5): p. 473-86.	Doesn't provide data on risk factors for acute fatigue.
Tregear, S., et al., Obstructive sleep apnea and risk of motor vehicle crash: systematic review and meta-analysis. J Clin Sleep Med, 2009. 5(6): p. 573-81.	Doesn't provide data on risk factors for acute fatigue.
Watt, T., et al., Fatigue in the Danish general population. Influence of sociodemographic factors and disease. J Epidemiol Community Health, 2000. 54(11): p. 827-33.	Not a review.
Wesensten, N.J., T.J. Balkin, and G. Belenky, Does sleep fragmentation impact recuperation? A review and reanalysis. J Sleep Res, 1999. 8(4): p. 237-45.	Doesn't provide data on risk factors for acute fatigue.
Young, T.B., Epidemiology of daytime sleepiness: definitions, symptomatology, and prevalence. J Clin Psychiatry, 2004. 65 Suppl 16: p. 12-6.	Doesn't provide data on risk factors for acute fatigue.

Appendix E: Risk of Bias (Study Quality) Assessment

Instruments Used

Table 129. Joanna Briggs Institute (JBI) Descriptive / Case-series Risk of Bias Assessment Tool

Item	Question
1	Was the study based on a random or pseudo-random sample? (Selection of total or consecutive sample also acceptable)
2	Were the criteria for inclusion in the sample clearly defined?
3	Were confounding factors identified, and strategies to deal with them stated?
4	Were outcomes assessed using objective criteria?
5	If comparisons were being made, was there sufficient description of groups?
6	Was follow-up carried out over a sufficient time period?
7	Were the outcomes of people who withdrew described and included in the analysis?
8	Were outcomes measured in a reliable way?
9	Was appropriate statistical analysis used?

Original version and instructions available at: http://www.joannabriggs.edu.au/documents/JBI-Reviewers%20Manual-2011%20HR.pdf

Table 130. JBI Controlled Trial Instrument

Item	Question
1	Was the assignment to treatment groups truly random?
2	Were participants blinded to treatment allocation?
3	Was allocation to treatment groups concealed from the allocator?
4	Were the outcomes of people who withdrew described and included in the analysis?
5	Were those assessing the outcomes blind to the treatment allocation?
6	Were the control and treatment groups comparable at entry?
7	Were groups treated identically other than for the named intervention?
8	Were outcomes measured in a reliable way?
9	Was appropriate statistical analysis used?

Original version and instructions available at: http://www.joannabriggs.edu.au/documents/JBI-Reviewers%20Manual-2011%20HR.pdf

Table 131. Newcastle-Ottawa Risk of Bias Assessment Scale for Case Control Studies (Revised)

Item	Question
1	Was exposure determined using independent or blind assessment or confirmation by objective records?
2	Are the exposed cohorts representative of the population of interest?
3	Are the nonexposed cohorts representative of the population of interest?
4	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?
5	Were cases and controls either matched or otherwise adjusted for the most important confounding factor?
6	Does the study control for any additional confounders?
7	Was the outcome assessed objectively?
8	Was the outcome assessor blinded to patient group allocation?
9	Was the same method of exposure/outcome ascertainment used for both groups?
10	Was the nonresponse rate (or rate of missing records) of both groups similar?

Original version and instructions available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp

Table 132. Newcastle-Ottawa Risk of Bias Assessment Scale for Cohort Studies (Revised)

Item	Question
1	Are the exposed cohorts representative of the population of interest?
2	Are the nonexposed cohorts representative of the population of interest?
3	Was exposure determined using independent or blind assessment or confirmation by objective records?
4	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?
5	Were cases and controls either matched or otherwise adjusted for confounding factors?
6	Was the outcome assessed objectively?
7	Was the duration of follow-up long enough for the outcome to occur?
8	Was the duration of follow-up long enough for both groups?

Original version and instructions available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp

Risk of Bias (Individual Study Quality) Assessment Tables

Key Question 1A: Crash

Table 133. Risk of Bias Assessment for Key Question 1A. Crash: Newcastle Ottawa Assessment Scale for Case Control Studies (Revised)

Reference	Year	Was exposure determined using independent or blind assessment or confirmation by objective records?	Are the exposed cohorts represent-active of the population of interest?	Are the nonexposed cohorts representative of the population of interest?	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?	Were cases and controls either matched or otherwise adjusted for the most important confounding factor?	Does the study control for any additional confounders?	Was the outcome assessor blinded to patient group allocation?	Was the same method of exposure /outcome ascertain-ment used for both groups?	Was the non-response rate (or rate of missing records) of both groups similar?	Risk of Bias Rating
Sando et al.[11]	2010	Yes	Yes	Yes	Not applicable	Not reported	No	No	Yes	Yes	Moderate
Jones and Stein[5]	1987	Yes	Yes	Yes	Not applicable	No (exposure)	Yes (time of day, day of week, road)	No	Yes	Yes	Moderate

Table 134: Risk of Bias Assessment for Key Question 1a, Crash: Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)

Reference	Year	Are the exposed cohorts representative of the population of interest?	Are the nonexposed cohorts representative of the population of interest?	Was exposure determined using independent or blind assessment or confirmation by objective records?	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?	Were cases and controls either matched or otherwise adjusted for confounding factors?	Was the outcome assessed objectively?	Was the duration of follow-up long enough for the outcome to occur?	Was the duration of follow-up long enough for both groups?	Rating
Jovanis et al[3].; Wu and Jovanis[4]	2011	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Moderate

Reference	Year	Are the exposed cohorts representative of the population of interest?	Are the nonexposed cohorts representative of the population of interest?	Was exposure determined using independent or blind assessment or confirmation by objective records?	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?	Were cases and controls either matched or otherwise adjusted for confounding factors?	Was the outcome assessed objectively?	Was the duration of follow-up long enough for the outcome to occur?	Was the duration of follow-up long enough for both groups?	Rating
Jovanis et al.[8]	1991	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Moderate
Kaneko and Jovanis[1]	1991	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Moderate
Park et al.[2]	Not Reported	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Moderate

Table 135: Risk of Bias Assessment for Key Question 1a, Crash: JBI Descriptive / Case-series Risk of Bias Assessment Tool

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Rating
Hickman et al.[7]	2005	No	No	No	Yes	N/A (comparison was time of day)	Yes	N/A	Yes	Yes	High
Massie et al.[9]	1997	Yes	Yes	No	Yes	N/A (comparison was time of day)	Yes	N/A	Yes	Yes	High

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Rating
McCartt et al.[6]	1997	Yes	Yes	No	Yes	N/A (comparison was time of day)	Yes	N/A	No (recall)	Yes	High
National Transportation Safety Board[10]	1996	Yes	Yes	No	Yes	N/A (comparison was time of day)	Yes	N/A	No (recall)	Yes	High

Key Question 1B: Driving Ability

Table 136: Risk of Bias Assessment for Key Question 1B, Driving Ability: Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)

Reference	Year	Are the exposed cohorts representative of the population of interest?	Are the nonexposed cohorts representative of the population of interest?	Was exposure determined using independent or blind assessment or confirmation by objective records?	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?	Were cases and controls either matched or otherwise adjusted for confounding factors?	Was the outcome assessed objectively?	Was the duration of follow-up long enough for the outcome to occur?	Was the duration of follow-up long enough for both groups?	Rating
NTRCI / Fine et al. [87]	2012	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Moderate

N/A – Not applicable; NR – Not reported

Table 137: Risk of Bias Assessment for Key Question 1B, Driving Ability: JBI Controlled Trial Instrument

Reference	Year	Was the assignment to treatment groups truly random?	Were participants blinded to treatment allocation?	Was allocation to treatment groups concealed from the allocator?	Were the outcomes of people who withdrew described and included in the analysis?	Were those assessing the outcomes blind to the treatment allocation?	Were the control and treatment groups comparable at entry?	Were groups treated identically other than for the named intervention?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Rating
Akerstadt et al.[97]	2005	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Lenne et al.[24]	1998	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Otmani et al. [23]	2005	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Park et al. [22]	2007	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Philip et al. [21]	2005	Yes	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Philip et al.[98]	2003	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Rossi et al.[93]	2011	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Sagaspe et al. [94]	2008	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Thiffault and Bergeron[99]	2003	No (but crossover)	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate
Vakulin et al. [18]	2007	Yes	No	No	N/A	No	Yes	Yes	Yes	Yes	Moderate

N/A – Not applicable

Table 138: Risk of Bias Assessment for Key Question 1B, Driving Ability: JBI Descriptive / Case-series Risk of Bias Assessment Tool

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Rating
Arnedt et al. [20]	2005	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Baulk et al. [160]	2008	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Howard et al. [90]	2007	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Kee et al. [88]	2010	No	No	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Matthews et al. [19]	2012	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Moller at el. [96]	2006	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Peters et al. [17]	1999	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Barr et al.[34]	2011	No	No	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Commercial Motor Vehicle Driver Fatigue and Alertness Study[64]	1997	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Drowsy Driver Warning System Study[12, 13]	2007 2009	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Fuller[92]	1983	No	No	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Hanowski et al.[91]	2003	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate
Naturalistic Truck	2011	No	No	Yes	Yes	N/A (same	Yes	N/A	Yes	Yes	Moderate

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Rating
Driving Study[14, 15]						group)					
Ting et al. [95]	2008	No	Yes	Yes	Yes	N/A (same group)	Yes	N/A	Yes	Yes	Moderate

N/A – Not applicable

Key Question 2

Table 139. Risk of Bias Assessment for Key Question 2: JBI Descriptive / Case-series Risk of Bias Assessment Tool

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Risk of Bias Rating
Barr et al.	2011	No	No	Yes	No	Yes	Yes	N/A	Yes	Yes	
Drowsy Driver Warning System Study: Hanowski et al.	2007	No	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes	
Naturalistic Truck Driving Study: Blanco et al.	2011	No	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes	
Perez Chada	2005	No	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes	
Boiven et al.[27]	NR	No	Yes	No	No	Yes	Yes	N/A*	Yes	Yes	High

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Risk of Bias Rating
Thomas and Ferguson[161]	2010	No	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes	High
Wylie 1998[28] **Wylie 1996**[102]	1998 1996	No	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes	High

N/A – Not applicable; NR – Not reported
*For all studies, no attrition was reported; however, the proportion that declined to participate was usually not reported
Gray shadingshows those studies with risk of sampling bias

Table 140. Risk of Bias Assessment for Key Question 2: JBI Controlled Trial Instrument

Reference	Year	Was the assignment to treatment groups truly random?	Were participants blinded to treatment allocation?	Was allocation to treatment groups concealed from the allocator?	Were the outcomes of people who withdrew described and included in the analysis?	Were those assessing the outcomes blind to the treatment allocation?	Were the control and treatment groups comparable at entry?	Were groups treated identically other than for the named intervention?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Risk of Bias Rating
Belenky et al. 2003[32] **Balkin et al. 2000[33]**	2003 2000	No	No	No	N/A	No	NR	Yes	Function: Yes Sleepiness: Yes (latency test) and No (Likert scale)	Yes	Moderate

N/A – Not applicable; NR – Not reported
Dark gray shading shows those studies with risk of sampling bias. Light gray shading shows those studies with risk of selection/group allocation bias.

Table 141. Risk of Bias Assessment for Key Question 2: Newcastle Ottawa Assessment Scale for Case Control Studies (Revised)

Reference	Year	Was exposure determined using independent or blind assessment or confirmation by objective records?	Are the exposed cohorts represent-active of the population of interest?	Are the nonexposed cohorts representative of the population of interest?	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?	Were cases and controls either matched or otherwise adjusted for the most important confounding factor?	Does the study control for any additional confounders?	Was the outcome assessor blinded to patient group allocation?	Was the same method of exposure /outcome ascertain-ment used for both groups?	Was the non-response rate (or rate of missing records) of both groups similar?	Risk of Bias Rating
Dorrian and Dawson[29]	2005	Yes	Yes	Yes	Yes	Yes –recent sleep and work history and shift duration regulation compliance, but not health	Yes (see left)	No	Yes	Yes	Moderate
Hertz	1988	Yes	Yes	Yes	Yes	Yes – time of day, day of week, driving environment	Yes (see left)	No	Yes	Yes	Moderate
Jovanis et al.[101]	2011	Yes	Yes	Yes	Yes	Yes – recent driving hours and patterns, time of day, breaks, and use of 34-hour recovery policy, but not health	Yes (company, terminal, month)	No	Yes	Yes	Moderate

Dark gray shading: risk of sampling bias. Light gray shading: risk of selection/group allocation bias.

Table 142. Risk of Bias Assessment for Key Question 2: Newcastle Ottawa Assessment Scale for Cohort Studies (Revised)

Reference	Year	Are the exposed cohorts representative of the population of interest?	Are the nonexposed cohorts representative of the population of interest?	Was exposure determined using independent or blind assessment or confirmation by objective records?	Does the study state or demonstrate that the outcome of interest was not present at the start of the study?	Were cases and controls either matched or otherwise adjusted for confounding factors?	Was the outcome assessed objectively?	Was the duration of follow-up long enough for the outcome to occur?	Was the duration of follow-up long enough for both groups?	Comments	Risk of Bias Rating
Powell et al.[162]	2010	Yes	Yes	Yes	Yes	No	Function: Yes Fatigue: No Sleepiness: No	Yes	Yes	Pilots	High
Lamond et al. 2006[163] **Lamond et al.**[164]	2006 2005	Unclear	Unclear	Yes	Yes	No	Function: Yes Fatigue: No	Yes	Yes	Pilots	High

Dark gray shading: risk of sampling bias. Light gray shading: risk of selection/group allocation bias.

Key Question 3

Table 143. Risk of Bias Assessment for Key Question 3: JBI Descriptive / Case-series Risk of Bias Assessment Tool

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Risk of Bias Rating
Anderson & Riley[112]	2008	Yes	Yes	Yes	No	N/A	N/A	No	Yes	No	High
Beilock[113]	2003	Yes	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	High
Blanco et al.[114]	2011	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Chiu et al.[115]	2011	Yes	No	Yes	No	N/A	N/A	Yes	Yes	No	High
Chiu et al.[116]	2010	Yes	Yes	Yes	No	N/A	N/A	No	Yes	No	High
Colt et al.[117]	2004	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	High
Couper et al.[118]	2002	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	No	High
Crum et al.[119]	2002	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Davis et al.[120]	2007	Yes	Yes	Yes	Yes	N/A	N/A	No	No	Yes	High
Dinges & Maislin[80]	2006	Yes	Yes	No	No	N/A	N/A	Yes	No	No	High
Escoto & French[121]	2012	Yes	Yes	No	Yes	N/A	N/A	No	Yes	No	High
Fine et al.[122]	2012	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Garshick et al.[124]	2002	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Garshick et al.[125]	2008	No	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	High
Howarth[126]	2002	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Jain et al.[127]	2006	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Kashima[128]	2003	No	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	High
Laden et al.[129]	2007	No	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	Moderate
Layne et al.[130]	2009	Yes	Yes	No	No	N/A	N/A	No	Yes	No	High
Martin et al.[131]	2009	Yes	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	High

Reference	Year	Was the study based on a random or pseudo-random sample?	Were the criteria for inclusion in the sample clearly defined?	Were confounding factors identified, and strategies to deal with them stated?	Were outcomes assessed using objective criteria?	If comparisons were being made, was there sufficient description of groups?	Was follow-up carried out over a sufficient time period?	Were the outcomes of people who withdrew described and included in the analysis?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Risk of Bias Rating
McCartt et al.[132]	2008	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Morrow & Crum[45]	2004	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Moderate
Pack et al.[133]	2002	No	No	No	No	N/A	N/A	No	No	No	High
Reed & Cronin[134]	2003	No	Yes	Yes	No	N/A	N/A	No	Yes	No	High
Robinson & Burnett[135]	2005	No	Yes	Yes	Yes	N/A	N/A	No	No	Yes	High
Rodriguez et al.[136]	2006	Yes	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	Moderate
Rodriguez et al.[137]	2003	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes	High
Sando & Moses[165]	2010	Yes	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	Moderate
Smith et al.[139]	2006	No	No	No	No	N/A	N/A	No	No	No	High
Smith & Phillips[140]	2011	Yes	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	Moderate
Solomon et al.[141]	2004	Yes	Yes	Yes	Yes	N/A	N/A	No	No	No	High
Stasko & Neale[142]	2007	Yes	Yes	No	No	N/A	N/A	Yes	Yes	No	High
Turner & Reed[143]	2011	Yes	No	Yes	Yes	N/A	N/A	No	Yes	Yes	High
Watkins et al.[144]	2009	No	Yes	No	Yes	N/A	N/A	No	Yes	Yes	High
Whitfield Jacobson et al. [145]	2007	Yes	No	No	Yes	N/A	N/A	No	Yes	No	High
Wiegand et al.[146]	2009	Yes	No	Yes	Yes	N/A	N/A	No	Yes	No	High
Xie et al.[147]	2011	No	Yes	Yes	Yes	N/A	N/A	No	Yes	Yes	High
Zhang et al.[148]	2005	No	Yes	Yes	No	N/A	N/A	No	Yes	Yes	High

N/A – Not applicable

Key Question 4

An assessment of literature reviews on fatigue and motorcoach drivers was not performed for this key question. No studies were found that examined the differences between coach and truck drivers and their fatigue risk. For Key Question 4, it was first necessary to independently identify the significant risk factors for acute fatigue via a literature review. Next, our task was to connect these fatigue risk factors with the demographic, job function, work environment, and health characteristics of coach and truck drivers examined in Key Question 3. Finally, we set about comparing the predominance of these fatigue risk factors among truck drivers as compared with their predominance in coach drivers.

Appendix F: Determining the Strength of Evidence

Table 144 identifies the risk of bias ratings of individual studies included in this report to determine the strength of evidence supporting our conclusions. Methodological experts identified these factors and reported them in methods literature. In the comprehensive review of available systems for rating the strength of scientific evidence, RTI-UNC EPC identified three constructs impacting strength of evidence:[166] the quality of the information included in the evidence base; the quantity of information in the evidence base; and the consistency of the information included in the evidence base. These constructs were later expanded upon by Treadwell, Tregear, Reston, & Turkelson[167], who argue magnitude of effect and robustness of the summary findings of the evidence base should also be considered.

Table 144. Factors Used to Assess the Strength of Evidence

Constructs	Definition
Overall Quality	The collective assessment of the factors that influence the credibility of individual studies composing a body of evidence
Quantity	The number of studies that have evaluated the given topic and the overall sample size across all included studies
Consistency	The degree to which different studies found similar results
Robustness	The degree to which minor alterations in the data do not change the conclusions
Magnitude of Effect	The effect size; indices that measure the magnitude of a treatment effect or the strength of the relationship between two variables

These constructs are closely interrelated. MANILA analysts considered these factors when determining whether an evidence-based conclusion was warranted, and to rate the strength of the evidence supporting conclusions.

Appendix G. Federal Regulatory Standards and Exceptions/Exemptions for Hours of Service

The FMCSA commercial license regulations regarding hours of service (HOS) for vehicle drivers are summarized in Table 145 along with the regulations of six countries/governing entities. Only regulations by the United States and European Union / United Kingdom are specific to passenger-carrying vehicles.

- **Australia** (Fatigue Management Scheme; 2011)[168]
- **Canada** (Canadian Council of Motor Transport Administrators [CCMTA] Commercial Vehicle Drivers Hours of Service Regulations; 2005)[169]
- **New Zealand** (Work Time and Logbooks; 2010)[168]
- **European Union and United Kingdom** (Rules on Driver's Hours and Tachographs: Passenger-Carrying Vehicles in GB and Europe; 2011)[170]
- **NAFTA** (Pilot Program on NAFTA Long-Haul Trucking Provisions; 2011)[171]

Table 145. Hours of Service Regulations

Country	Hours of Service	Exceptions and Exemptions
United States	Standard § 395.5 Maximum driving time for passenger-carrying vehicles. Subject to the exceptions and exemptions in §395.1: (a) No motor carrier shall permit or require any driver used by it to drive a passenger-carrying commercial motor vehicle, nor shall any such driver drive a passenger-carrying commercial motor vehicle: (1) More than 10 hours following 8 consecutive hours off duty; or (2) For any period after having been on duty 15 hours following 8 consecutive hours off duty. (b) No motor carrier shall permit or require a driver of a passenger-carrying commercial motor vehicle to drive, nor shall any driver drive a passenger-carrying commercial motor vehicle, regardless of the number of motor carriers using the driver's services, for any period after— (1) Having been on duty 60 hours in any 7 consecutive days if the employing motor carrier does not operate commercial motor vehicles every day of the week; or (2) Having been on duty 70 hours in any period of 8 consecutive days if the employing motor carrier operates commercial motor vehicles every day of the week. [70 FR 50073, Aug. 25, 2005] 10-hour Driving Limit May drive a maximum of 10 hours after 8 consecutive hours off duty 15-Hour On-Duty Limit May not drive after having been on duty for 15 hours, following 8 consecutive hours off duty. Off-duty time is not included in the 15-hour period. 60/70-Hour On-Duty Limit May not drive after 60/70 hours on duty in 7/8 consecutive days Sleeper Berth Provision Drivers using the sleeper berth provision must take a least 8 consecutive hours in the sleeper berth, and may split the sleeper-berth time into two periods provided neither is less than 2 hours	Yes – Table 146

<table>
<tr><th>Country</th><th>Hours of Service</th><th>Exceptions and Exemptions</th></tr>
<tr><td>Australia</td><td>
New South Wales
Solo Driver
<table>
<tr><td>Total period</td><td>Maximum work time</td><td>Minimum rest time</td></tr>
<tr><td>In any period of…</td><td>a driver must not work for more than a total of</td><td>and must have at least…</td></tr>
<tr><td>5 hrs 30 mins</td><td>5 hrs 15 mins</td><td>15 continuous mins rest</td></tr>
<tr><td>8 hrs</td><td>7 hrs 30 mins</td><td>30 mins rest, in blocks of 15 continuous minutes</td></tr>
<tr><td>11 hrs</td><td>10 hrs</td><td>60 mins rest, in blocks of 15 continuous mins</td></tr>
<tr><td>24 hrs</td><td>12 hrs</td><td>7 continuous hrs stationary* rest</td></tr>
<tr><td>7 days (168 hrs)</td><td>72 hrs</td><td>24 continuous hrs stationary* rest</td></tr>
<tr><td>14 days (336 hrs)</td><td>144 hrs</td><td>4 night rests** (includes 2 consecutive night rests)</td></tr>
</table>
Two-up Drivers
<table>
<tr><td>Total period</td><td>Maximum work time</td><td>Minimum rest time</td></tr>
<tr><td>In any period of…</td><td>a driver must not work for more than a total of</td><td>and must have at least…</td></tr>
<tr><td>5 hrs 30 mins</td><td>5 hrs 15 mins</td><td>15 continuous minutes rest</td></tr>
<tr><td>8 hrs</td><td>7 hrs 30 mins</td><td>30 mins rest, in blocks of 15 continuous minutes</td></tr>
<tr><td>11 hrs</td><td>10 hrs</td><td>60 mins rest, in blocks of 15 continuous minutes</td></tr>
<tr><td>24 hrs</td><td>12 hrs</td><td>5 continuous hrs stationary rest or 5 continuous hrs rest time in an approv sleeper berth while the vehicle is moving</td></tr>
<tr><td>52 hrs</td><td>(Intentionally left blank)</td><td>10 hrs continuous stationary* rest</td></tr>
<tr><td>7 days (168 hrs)</td><td>60 hrs</td><td>24 hrs continuous stationary* rest time and 24 hrs stationary rest time in blocks of at least 7 continuous hrs stationary rest</td></tr>
<tr><td>14 days (336 hrs)</td><td>120 hrs</td><td>4 nights rests** (includes 2 consecutive night rests)</td></tr>
</table>
Western Australia
(1) A commercial vehicle driver must, so far as practicable, have –
(a) for every 5 hours work time – breaks from driving totaling at least 20 minutes including a break from driving of at least 10
</td><td></td></tr>
</table>

Country	Hours of Service	Exceptions and Exemptions
	consecutive minutes after 5 hours work time; and (b) in any 14 day period – no more than 168 hours of work time. (2) In addition to subregulation (1), a commercial vehicle driver who drives without a relief driver must, so far as practicable, have – (a) in any 72 hour period – at least 27 hours non-work time, including at least 3 periods of at least 7 consecutive hours non-work time, with each period separated from the next by not more than 17 hours; and (b) either – (i) in any 14 day period – at least 2 periods of 24 consecutive hours non-work time; or (ii) in any 28 day period – at least 4 periods of 24 consecutive hours non-work time if, and only if, the driver has no more than 144 hours work time in any 14 day period that is part of the 28 day period. (3) In addition to subregulation (1), a commercial vehicle driver who drives with a relief driver must, so far as practicable, have – (a) in any 24 hour period – at least 7 hours of non-work time, whether or not the time is spent in the vehicle while it is moving; and (b) either – (i) in any 48 hour period – at least one period of 7 continuous hours nonwork time, which time is not spent in the vehicle while it is moving; or (ii) in any 7 day period – at least 48 hours of non-work time, which time is not spent in the vehicle while it is moving, includes a period of at least 24 consecutive hours non-work time and does not include a period of nonwork time of less than 7 consecutive hours. (4) In addition to sub-regulation (1), a commercial vehicle driver who does shiftwork on 5 or more consecutive days must, so far as practicable, have at least 24 continuous hours of non-work time between shift changes.	
Canada	**11.** Sections 12 to 29 apply in respect of driving south of latitude 60°N. DAILY DRIVING AND ON-DUTY TIME **12.** (1) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated 13 hours of driving time in a day. (2) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated 14 hours of on-duty time in a day. MANDATORY OFF-DUTY TIME **13.** (1) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated 13 hours of driving time unless the driver takes at least 8 consecutive hours of off-duty time before driving again. (2) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated 14 hours of on-duty time unless the driver takes at least 8 consecutive hours of off-duty time before driving again. (3) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after 16 hours of time have elapsed between the conclusion of the most recent period of 8 or more consecutive hours of off-duty time and the beginning of the next period of 8 or more consecutive hours of off-duty time. DAILY OFF-DUTY TIME **14.** (1) A motor carrier shall ensure that a driver takes and the driver shall take at least 10 hours of off-duty time in a day.	

Country	Hours of Service	Exceptions and Exemptions
	(2) Off-duty time other than the mandatory 8 consecutive hours may be distributed throughout the day in blocks of no less than 30 minutes each. (3) The total amount of off-duty time taken by a driver in a day shall include at least 2 hours of off-duty time that does not form part of a period of 8 consecutive hours of off-duty time required by section 13. DEFERRAL OF DAILY OFF-DUTY TIME **16.** Despite sections 12 and 14, a driver who is not splitting off-duty time in accordance with section 18 or 19 may defer a maximum of 2 hours of the daily off-duty time to the following day if (*a*) the off-duty time deferred is not part of the mandatory 8 consecutive hours of off-duty time; (*b*) the total off-duty time taken in the 2 days is at least 20 hours; (*c*) the off-duty time deferred is added to the 8 consecutive hours of off-duty time taken in the second day; (*d*) the total driving time in the 2 days does not exceed 26 hours; and (*e*) there is a declaration in the "Remarks" section of the daily log that states that the driver is deferring off-duty time under this section and that clearly indicates whether the driver is driving under day one or day two of that time. CYCLES **24.** A motor carrier shall require that a driver follows and the driver shall follow either cycle 1 or cycle 2. **25.** Subject to section 28, no motor carrier shall request, require or allow a driver to drive and no driver shall drive unless the driver has taken at least 24 consecutive hours of off-duty time in the preceding 14 days. **26.** Subject to section 28, no motor carrier shall request, require or allow a driver who is following cycle 1 to drive and no driver who is following cycle 1 shall drive after the driver has accumulated 70 hours of on-duty time during any period of 7 days or, if the driver has reset the cycle in accordance with section 28, during the period of the cycle that was ended. **27.** Subject to section 28, no motor carrier shall request, require or allow a driver who is following cycle 2 to drive and no driver who is following cycle 2 shall drive after the driver has accumulated (*a*) 120 hours of on-duty time during any period of 14 days or, if the driver has reset the cycle in accordance with section 28, during the period of the cycle that was ended; or (*b*) 70 hours of on-duty time without having taken at least 24 consecutive hours of off-duty time. CYCLE RESET — OFF-DUTY TIME **28.** (1) A driver may end the current cycle and begin a new cycle if the driver first takes the following off-duty time: (*a*) for cycle 1, at least 36 consecutive hours; or (*b*) for cycle 2, at least 72 consecutive hours. (2) After taking the off-duty time, the driver begins a new cycle, the accumulated hours are set back to zero and the driver's hours begin to accumulate again. CYCLE SWITCHING — OFF-DUTY TIME	

Country	Hours of Service	Exceptions and Exemptions
	29. (1) No motor carrier shall request, require or allow a driver to switch and no driver shall switch from one cycle to the other without first taking the following off-duty time before beginning to drive again: (*a*) to switch from cycle 1 to cycle 2, at least 36 consecutive hours; or (*b*) to switch from cycle 2 to cycle 1, at least 72 consecutive hours. (2) After taking the off-duty time, the driver begins the other cycle, the accumulated hours are set back to zero and the driver's hours begin to accumulate again. SCHEDULING — DRIVING NORTH OF LATITUDE 60°N APPLICATION **37.** Sections 38 to 54 apply in respect of driving north of latitude 60°N. DRIVING AND ON-DUTY TIME **38.** (1) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated 15 hours of driving time. (2) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated 18 hours of on-duty time. MANDATORY OFF-DUTY TIME **39.** (1) No motor carrier shall request, require or allow a driver to drive and no driver shall drive after the driver has accumulated more than 15 hours of driving time or 18 hours of on-duty time unless they take at least 8 consecutive hours of off-duty time before driving again. (2) No motor carrier shall request, require or allow a driver to drive and no driver shall drive if more than 20 hours of time has elapsed between the conclusion of the most recent period of 8 or more consecutive hours of off-duty time and the beginning of the next period of 8 or more consecutive hours of off-duty time. DAILY OFF-DUTY TIME **40.** A motor carrier shall ensure that a driver takes and the driver shall take at least 8 hours of off-duty time. SPLITTING OF DAILY OFF-DUTY TIME — SINGLE DRIVER **41.** (1) A driver who is driving a commercial vehicle fitted with a sleeper berth may meet the mandatory off-duty time and daily off-duty time requirements of sections 39 and 40 by accumulating off-duty time in no more than 2 periods if (*a*) neither period of off-duty time is shorter than 2 hours; (*b*) the total of the 2 periods of off-duty time is at least 8 hours; (*c*) the off-duty time is spent resting in the sleeper berth; (*d*) the total of the driving time in the periods immediately before and after each of the periods of off-duty time does not exceed 15 hours; (*e*) the on-duty time in the periods immediately before and after each of the periods of off-duty time does not include any driving time after the 18th hour after the driver comes on duty, calculated in accordance with subsection (2); and	

Country	Hours of Service	Exceptions and Exemptions
	(*f*) none of the daily off-duty time is deferred to the next day. (2) The 18th hour is calculated by (*a*) excluding any period spent in the sleeper berth that is 2 hours or more in duration and that, when added to a subsequent period in the sleeper berth, totals at least 8 hours; and (*b*) including (i) all on-duty time, (ii) all off-duty time not spent in the sleeper berth, (iii) all periods of less than 2 hours spent in the sleeper berth, and (iv) any other period spent in the sleeper berth that does not qualify as counting towards meeting the requirements of this section. (3) No motor carrier shall request, require or allow the driver to begin to drive again in accordance with the requirements of sections 39 and 40 and no driver shall begin to drive again without first taking at least 8 consecutive hours of off-duty time. SPLITTING OF DAILY OFF-DUTY TIME — TEAM OF DRIVERS **42.** (1) A team of drivers driving a commercial vehicle fitted with a sleeper berth may meet the mandatory off-duty time and daily off-duty time requirements of sections 39 and 40 by accumulating off-duty time in no more than 2 periods if (*a*) neither period of off-duty time is shorter than 4 hours; (*b*) the total of the 2 periods of off-duty time is at least 8 hours; (*c*) the off-duty time is spent resting in the sleeper berth; (*d*) the total of the driving time in the periods immediately before and after each of the periods of off-duty time does not exceed 15 hours; (*e*) the on-duty time in the periods immediately before and after each of the periods of off-duty time does not include any driving time after the 18th hour after the driver comes on duty, calculated in accordance with subsection (2); and (*f*) none of the off-duty time is deferred to the next day. (2) The 18th hour is calculated by (*a*) excluding any period spent in the sleeper berth that is 4 hours or more in duration and that, when added to a subsequent period in the sleeper berth, totals at least 8 hours; and (*b*) including (i) all on-duty time, (ii) all off-duty time not spent in the sleeper berth, (iii) all periods of less than 4 hours spent in the sleeper berth, and (iv) any other period spent in the sleeper berth that does not qualify as counting towards meeting the requirements of this section. (3) No motor carrier shall request, require or allow the driver to begin to drive again in accordance with the requirements of sections	

Country	Hours of Service	Exceptions and Exemptions
	39 and 40 and no driver shall begin to drive again without first taking at least 8 consecutive hours of off-duty time. CYCLES **49.** A motor carrier shall require that a driver follows and the driver shall follow either cycle 1 or cycle 2. **50.** Subject to section 53, no motor carrier shall request, require or allow a driver to drive and no driver shall drive unless the driver has taken at least 24 consecutive hours of off-duty time in the preceding 14 days. **51.** Subject to section 53, no motor carrier shall request, require or allow a driver who is following cycle 1 to drive and no driver who is following cycle 1 shall drive after the driver has accumulated 80 hours of on-duty time during any period of 7 days. **52.** Subject to section 53, no motor carrier shall request, require or allow a driver who is following cycle 2 to drive and no driver who is following cycle 2 shall drive after the driver has accumulated (*a*) 120 hours of on-duty time in any period of 14 days; or (*b*) 80 hours of on-duty time, without having taken at least 24 consecutive hours of off-duty time. CYCLE RESET — OFF-DUTY TIME **53.** (1) A driver may end the current cycle and begin a new cycle if they first take the following off-duty time: (*a*) for cycle 1, at least 36 consecutive hours; or (*b*) for cycle 2, at least 72 consecutive hours. (2) After taking the off-duty time, the driver begins a new cycle, the accumulated hours are set back to zero and the driver's hours begin to accumulate again. CYCLE SWITCHING — OFF-DUTY TIME **54.** (1) No motor carrier shall request, require or allow a driver to switch and no driver shall switch from one cycle to the other without first taking the following off-duty time before beginning to drive again: (*a*) to switch from cycle 1 to cycle 2, at least 36 consecutive hours; or (*b*) to switch from cycle 2 to cycle 1, at least 72 consecutive hours. (2) After taking the off-duty time, the driver begins the other cycle, the accumulated hours are set back to zero and the driver's hours begin to accumulate again.	
New Zealand	Work time requirements Work time applies to anyone legally required to manage driving hours, including transport service operators and drivers, organizations that employ or contract drivers and transport logistics companies. Work time is time spent performing work-related duties, including driving vehicles, loading and unloading vehicles, maintaining and cleaning vehicles, administration or recording and any other paid employment. In general*, drivers must take a break of at least 30 minutes after 5½ hours of work time - no matter what type of work takes place during that period. * Because taxi drivers' work typically involves 'unofficial' periods of rest while waiting for a fare, in most cases taxi drivers can work	*Delays due to unforeseen circumstances* Special provisions cover situations where drivers are prevented from completing their journey within work time limits due to an unforeseen situation or an emergency.

Country	Hours of Service	Exceptions and Exemptions
	for 7 hours before taking a break of at least 30 minutes. *After 13 hours* In any cumulative work day (legally defined as no more than 24 hours), drivers can work a maximum of 13 hours and must then take a break of at least 10 hours (as well as the standard half-hour breaks required every 5½ hours). *After 70 hours* Drivers can accumulate work time of up to 70 hours before they must take a break of at least 24 hours. The time between one 24-hour break and the next is legally described as a 'cumulative work period'. A cumulative work period will be made up of a collection of cumulative work days, where drivers have taken the necessary breaks to meet their work time requirements. *Chain of responsibility* If you employ or control drivers who are subject to work time requirements and you knew, or should have known, that a driver under your control did, or was likely to, breach work time provisions, you could face fines of up to $25,000 if convicted.	Three situations are specified as emergency events: a civil defense emergency an incident attended by an emergency service urgent action to save life or prevent injury. If you are delayed due to unforeseen circumstances, this must be recorded in your logbook. *Emergency and essential drivers* The law allows emergency and essential service workers to exceed work time limits in some circumstances. In addition, volunteer fire fighters and volunteer ambulance drivers are not subject to work time limits when they undertake priority calls. For more information, see the NZTA publication **Work time and logbooks** or check the Land Transport Rule: Work Time and Logbooks 2007.
European Union	European Union rules on drivers' hours The European Union (EU) drivers' hours rules set limits for daily, weekly and fortnightly driving. The rules also specify minimum breaks for drivers during the working day, and daily and weekly rest periods. The main points of the EU rules are: Daily driving must not exceed nine hours, although this may be extended to ten hours twice a week.	Vehicles used for the carriage of passengers on regular services with a route that does not exceed 50 km Vehicles not capable of

Country	Hours of Service	Exceptions and Exemptions
	Weekly driving must not exceed 56 hours. Fortnightly driving must not exceed 90 hours in any two consecutive weeks. Drivers must take breaks that total at least 45 minutes during or after a maximum of 4.5 hours of driving. The break can be split into two periods, one of at least 15 minutes followed by one of at least 30 minutes. You cannot split breaks into three periods of 15 minutes. Drivers must normally take at least 11 consecutive hours of daily rest. This can be reduced by up to two hours on no more than three occasions between any two weekly rest periods. Drivers may split their daily rest into two periods totaling 12 hours. If they do, the first period must be at least three hours and the second at least nine hours. You cannot split daily rest into more than two periods. Within six 24-hour periods from the end of their last weekly rest, drivers must extend their daily rest period into a weekly rest period. This may be either the regular 45-hour weekly rest or a reduced period of at least 24 hours. With effect from 4 June 2010, the weekly rest requirement for drivers on international occasional coach journeys changes. The concession allows drivers on single international journeys to postpone their weekly rest period until the end of the twelfth day. It also requires the driver to take a regular 45 hour rest prior to the journey beginning, in addition to requiring at least one regular and one reduced weekly rest period back-to-back on the journey's completion, which amounts to a minimum rest period of at least 69 hours.	exceeding 40 km/h. Vehicles owned or hired without a driver by the Armed Services, civil defense services, fire services and forces responsible for maintaining public order, when the carriage is undertaken as a consequence of the tasks assigned to these services and is under their control. Vehicles undergoing road tests for technical development, repair or maintenance purposes, and new or rebuilt vehicles that have not yet been put into service Vehicles, including vehicles used in the non-commercial transport of humanitarian aid, used in emergencies or rescue operations. Specialized vehicles used for medical purposes. Commercial vehicles that have a historic status according to the legislation of the member state in which they are driven and are used for the noncommercial carriage of passengers or goods.
United	GB drivers' hours rules	Exemptions

Country	Hours of Service	Exceptions and Exemptions
Kingdom	Driving and duty limits under GB drivers' hours rules Under the GB drivers' hours rules you are allowed to drive for a maximum of ten hours in any 24-hour period. The definition of driving is being at the controls of a vehicle for the purposes of controlling its movement with the engine running. This applies whether it is moving or stationary. The total amount of time you are permitted to be 'on duty' for in the same 24-hour period, is 11 hours. If you are a driver employed in a company or the director of a limited company, 'on duty' is defined as any working time, eg sweeping the yard, answering the phone or loading and unloading. If you are a self-employed driver, 'on duty' means driving the vehicle or carrying out any other work in connection with the vehicle or its load. Answering the phone or sweeping the yard would not count as time on duty, but cleaning a van or loading it up would be. Note that if you drive for fewer than four hours in a day, there are no restrictions on duty time. Regulations on working time The Working Time Regulations 1998 will apply to you if you drive under the GB rules. These regulations set a maximum 48-hour working week, a right to 4.8 weeks of annual leave, and also a right to health checks and adequate rest. For more information, see our guide on drivers' hours rules: the basics. Driving limits, rest periods and breaks under GB drivers' hours rules Domestic driving limits apply to drivers and operators of both goods and passenger carrying vehicles. For drivers of goods vehicles, to comply with the GB domestic drivers' hours rules, you must: ensure that in any working day the maximum amount of driving you do is ten hours ensure that in any working day your maximum amount of duty time is eleven hours For more about what is meant by driving and duty limits, see the page in this guide on driving and duty limits under GB drivers' hours rules. If you drive passenger vehicles, to comply with the GB rules you must: Take a break of at least 30 minutes when you have been driving for 5.5 hours. Alternatively, within a period of 8.5 hours, you must take breaks that add up to at least 45 minutes. This is so that you are not driving for more than seven hours and 45 minutes. You must take an additional break of 30 minutes at the end of this period to get refreshments, unless it is the end of the day. Ensure that in any working day the maximum amount of driving is ten hours. You should also make sure that you should work no more than 16 hours between the times of starting and finishing work. Take a continuous rest of ten hours between two consecutive working days. You can reduce this to 8.5 hours up to three times a week. Have at least one period of 24 hours off duty in any two consecutive weeks. If you do not comply with the drivers' hours rules you could be penalized and in some cases even prosecuted. For more information, see the page in this guide on penalties you may face for breaching GB drivers' hours rules.	The GB rules do not apply to drivers who do not use public roads, eg, driving in connection with road improvements or road maintenance, quarrying, construction work and civil engineering works. If you drive for fewer than four hours every day in any fixed week, you do not have to meet the drivers' hours requirement for that week. A **fixed week** runs from 00.00 on Sunday to 00.00 the next Sunday. Emergencies You are allowed to break the GB rules on driving and duty limits if you need to take immediate action to avoid: danger to the life of people or animals; serious interruption of essential public services (gas, water, electricity and drainage), of telecommunication or postal services, or in the use of roads, railways, ports or airports; serious damage to property
NAFTA – Mexico-	Measures To Protect the Health and Safety of the Public The FMCSA has developed an extensive oversight system to protect the health and safety of the public and FMCSA will apply it to	

Country	Hours of Service	Exceptions and Exemptions
domiciled carriers	Mexico-domiciled motor carriers. These measures are outlined in 49 CFR parts 350-396 and include providing grants to States for commercial vehicle enforcement activities, regulations outlining the application procedures, regulations explaining how FMCSA will assess safety ratings and civil penalties as well as amounts of possible civil penalties, insurance requirements, drug and alcohol testing requirements, commercial driver's license (CDL) requirements, general operating requirements, driver qualification requirements, vehicle parts and maintenance requirements, and hours-of-service requirements. These requirements apply to Mexico-domiciled carriers operating in this pilot program, just as they do to any commercial motor vehicle, driver, or carrier operating in the United States.	

Table 146 contains the federal regulatory standards found in the FMCSRs (49 C.F.R. section 395.5) that specifically apply to the HOS regulations for drivers of passenger-carrying vehicles. A link to the complete FMCSRs can be found in the report index.

Table 146: FMCSRs Regulatory Standards for Maximum Driving Time for Passenger-Carrying Vehicles

Country	United States
Source	http://www.fmcsa.dot.gov/rules-regulations/administration/medical.htm
STANDARD	§ 395.5Maximum driving time for passenger-carrying vehicles. Subject to the exceptions and exemptions in §395.1: (a) No motor carrier shall permit or require any driver used by it to drive a passenger-carrying commercial motor vehicle, nor shall any such driver drive a passenger-carrying commercial motor vehicle: (1) More than 10 hours following 8 consecutive hours off duty; or (2) For any period after having been on duty 15 hours following 8 consecutive hours off duty. (b) No motor carrier shall permit or require a driver of a passenger-carrying commercial motor vehicle to drive, nor shall any driver drive a passenger-carrying commercial motor vehicle, regardless of the number of motor carriers using the driver's services, for any period after— (1) Having been on duty 60 hours in any 7 consecutive days if the employing motor carrier does not operate commercial motor vehicles every day of the week; or (2) Having been on duty 70 hours in any period of 8 consecutive days if the employing motor carrier operates commercial motor vehicles every day of the week. [70 FR 50073, Aug. 25, 2005]
Exceptions and Exemptions (Passenger-carrying vehicle information has been highlighted)	§ 395.1Scope of rules in this part. (a) General. (1) The rules in this part apply to all motor carriers and drivers, except as provided in paragraphs (b) through (r) of this section. (2) The exceptions from Federal requirements contained in paragraphs (l) and (m) of this section do not preempt State laws and regulations governing the safe operation of commercial motor vehicles. (b) Adverse driving conditions. (1) Except as provided in paragraph (h)(2) of this section, a driver who encounters adverse driving conditions, as defined in §395.2, and cannot, because of those conditions, safely complete the run within the maximum driving time permitted by § 395.3(a) or § 395.5(a) may drive and be permitted or required to drive a commercial motor vehicle for not more than 2 additional hours in order to complete that run or to reach a place offering safety for the occupants of the commercial motor vehicle and security for the commercial motor vehicle and its cargo. However, that driver may not drive or be permitted to drive— (i) For more than 13 hours in the aggregate following 10 consecutive hours off duty for drivers of property-carrying commercial motor vehicles ;(ii) After the end of the 14th hour since coming on duty following 10 consecutive hours off duty for drivers of property-carrying commercial motor vehicles; **(iii) For more than 12 hours in the aggregate following 8 consecutive hours off duty for drivers of passenger-carrying commercial motor vehicles; or** **(iv) After he/she has been on duty 15 hours following 8 consecutive hours off duty for drivers of passenger-carrying commercial motor vehicles.** (2) Emergency conditions. In case of any emergency, a driver may complete his/her run without being in violation of the provisions of the regulations in this part, if such run reasonably could have been completed absent the emergency. (c) Driver-salesperson. The provisions of §395.3(b) shall not apply to any driver-salesperson whose total driving time does not exceed 40 hours in any period of 7

Country	United States
	consecutive days. (d) Oilfield operations. (1) In the instance of drivers of commercial motor vehicles used exclusively in the transportation of oilfield equipment, including the stringing and picking up of pipe used in pipelines, and servicing of the field operations of the natural gas and oil industry, any period of 8 consecutive days may end with the beginning of any off-duty period of 24 or more successive hours. (2) In the case of specially trained drivers of commercial motor vehicles which are specially constructed to service oil wells, on-duty time shall not include waiting time at a natural gas or oil well site; provided, that all such time shall be fully and accurately accounted for in records to be maintained by the motor carrier. Such records shall be made available upon request of the Federal Motor Carrier Safety Administration. (e) Short-haul operations—(1) 100 air-mile radius driver. A driver is exempt from the requirements of § 395.8 if: (i) The driver operates within a 100 air-mile radius of the normal work reporting location; (ii) The driver, except a driver-salesperson, returns to the work reporting location and is released from work within 12 consecutive hours; (iii)(A) A property-carrying commercial motor vehicle driver has at least 10 consecutive hours off duty separating each 12 hours on duty; **(B) A passenger-carrying commercial motor vehicle driver has at least 8 consecutive hours off duty separating each 12 hours on duty;** (iv)(A) A property-carrying commercial motor vehicle driver does not exceed 11 hours maximum driving time following 10 consecutive hours off-duty; or **(B) A passenger-carrying commercial motor vehicle driver does not exceed 10 hours maximum driving time following 8 consecutive hours off duty; and** (v) The motor carrier that employs the driver maintains and retains for a period of 6 months accurate and true time records showing: (A) The time the driver reports for duty each day; (B) The total number of hours the driver is on duty each day; (C) The time the driver is released from duty each day; and (D) The total time for the preceding 7 days in accordance with §395.8(j)(2) for drivers used for the first time or intermittently. (2) Operators of property-carrying commercial motor vehicles not requiring a commercial driver's license. Except as provided in this paragraph, a driver is exempt from the requirements of § 395.3 and § 395.8 and ineligible to use the provisions of §395.1(e)(1), (g) and (o) if: (i) The driver operates a property-carrying commercial motor vehicle for which a commercial driver's license is not required under part 383 of this subchapter; (ii) The driver operates within a 150 air-mile radius of the location where the driver reports to and is released from work, ie, the normal work reporting location; (iii) The driver returns to the normal work reporting location at the end of each duty tour; (iv) The driver has at least 10 consecutive hours off duty separating each on-duty period; (v) The driver does not drive more than 11 hours following at least 10 consecutive hours off-duty; (vi) The driver does not drive: A) After the 14th hour after coming on duty on 5 days of any period of 7 consecutive days; and (B) After the 16th hour after coming on duty on 2 days of any period of 7 consecutive days;(vii) The driver does not drive: (A) After having been on duty for 60 hours in 7 consecutive days if the employing motor carrier does not operate commercial motor vehicles every day of the week; (B) After having been on duty for 70 hours in 8 consecutive days if the employing motor carrier operates commercial motor vehicles every day of the week;

Country	United States
	(viii) Any period of 7 or 8 consecutive days may end with the beginning of any off-duty period of 34 or more consecutive hours. (ix) The motor carrier that employs the driver maintains and retains for a period of 6 months accurate and true time records showing: (A) The time the driver reports for duty each day; (B) The total number of hours the driver is on duty each day; (C) The time the driver is released from duty each day; (D) The total time for the preceding 7 days in accordance with § 395.8(j)(2) for drivers used for the first time or intermittently. (f) Retail store deliveries. The provisions of § 395.3 (a) and (b) shall not apply with respect to drivers of commercial motor vehicles engaged solely in making local deliveries from retail stores and/or retail catalog businesses to the ultimate consumer, when driving solely within a 100-air mile radius of the driver's work-reporting location, during the period from December 10 to December 25, both inclusive, of each year. (g) Sleeper berths—(1) Property-carrying commercial motor vehicle—(i) In General. A driver who operates a property-carrying commercial motor vehicle equipped with a sleeper berth, as defined in §§395.2 and 393.76 of this subchapter, (A) Must, before driving, accumulate (1) At least 10 consecutive hours off duty; (2) At least 10 consecutive hours of sleeper-berth time; (3) A combination of consecutive sleeper-berth and off-duty time amounting to at least 10 hours; or (4) The equivalent of at least 10 consecutive hours off duty if the driver does not comply with paragraph (g)(1)(i)(A)(1), (2), or (3) of this section; (B) May not drive more than 11 hours following one of the 10-hour off-duty periods specified in paragraph (g)(1)(i)(A)(1) through (4) of this section; and (C) May not drive after the 14th hour after coming on duty following one of the 10-hour off-duty periods specified in paragraph (g)(1)(i)(A)(1) through (4) of this section; and (D) Must exclude from the calculation of the 14-hour limit any sleeper berth period of at least 8 but less than 10 consecutive hours. (ii) Specific requirements. The following rules apply in determining compliance with paragraph (g)(1)(i) of this section: (A) The term "equivalent of at least 10 consecutive hours off duty" means a period of (1) At least 8 but less than 10 consecutive hours in a sleeper berth, and (2) A separate period of at least 2 but less than 10 consecutive hours either in the sleeper berth or off duty, or any combination thereof. (B) Calculation of the 11-hour driving limit includes all driving time; compliance must be re-calculated from the end of the first of the two periods used to comply with paragraph (g)(1)(ii)(A) of this section. (C) Calculation of the 14-hour limit includes all time except any sleeper-berth period of at least 8 but less than 10 consecutive hours; compliance must be re-calculated from the end of the first of the two periods used to comply with the requirements of paragraph (g)(1)(ii)(A) of this section. (2) Specially trained driver of a specially constructed oil well servicing commercial motor vehicle at a natural gas or oil well location. A specially trained driver who operates a commercial motor vehicle specially constructed to service natural gas or oil wells that is equipped with a sleeper berth, as defined in §§ 395.2 and 393.76 of this subchapter, or who is off duty at a natural gas or oil well location, may accumulate the equivalent of 10 consecutive hours off duty time by taking a combination of at least 10 consecutive hours of off-duty time, sleeper-berth time, or time in other sleeping accommodations at a natural gas or oil well location; or by taking two periods of rest in a sleeper berth, or other sleeping accommodation at a natural gas or oil well location, providing: (i) Neither rest period is shorter than 2 hours;

Country	United States
	(ii) The driving time in the period immediately before and after each rest period, when added together, does not exceed 11 hours; (iii) The driver does not drive after the 14th hour after coming on duty following 10 hours off duty, where the 14th hour is calculated: (A) By excluding any sleeper berth or other sleeping accommodation period of at least 2 hours which, when added to a subsequent sleeper berth or other sleeping accommodation period, totals at least 10 hours, and (B) By including all on-duty time, all off-duty time not spent in the sleeper berth or other sleeping accommodations, all such periods of less than 2 hours, and any period not described in paragraph (g)(2)(iii)(A) of this section; and (iv) The driver may not return to driving subject to the normal limits under § 395.3 without taking at least 10 consecutive hours off duty, at least 10 consecutive hours in the sleeper berth or other sleeping accommodations, or a combination of at least 10 consecutive hours off duty, sleeper berth time, or time in other sleeping accommodations. (**3) Passenger-carrying commercial motor vehicles. A driver who is driving a passenger-carrying commercial motor vehicle that is equipped with a sleeper berth, as defined in §§ 395.2 and 393.76 of this subchapter, may accumulate the equivalent of 8 consecutive hours of off-duty time by taking a combination of at least 8 consecutive hours off-duty and sleeper berth time; or by taking two periods of rest in the sleeper berth, providing:** **(i) Neither rest period is shorter than two hours;** **(ii) The driving time in the period immediately before and after each rest period, when added together, does not exceed 10 hours;** **(iii) The on-duty time in the period immediately before and after each rest period, when added together, does not include any driving time after the 15th hour; and** **(iv) The driver may not return to driving subject to the normal limits under § 395.5 without taking at least 8 consecutive hours off duty, at least 8 consecutive hours in the sleeper berth, or a combination of at least 8 consecutive hours off duty and sleeper berth time.** (h) State of Alaska—(1) Property-carrying commercial motor vehicle. The provisions of § 395.3(a) and (b) do not apply to any driver who is driving a commercial motor vehicle in the State of Alaska. A driver who is driving a property-carrying commercial motor vehicle in the State of Alaska must not drive or be required or permitted to drive— (i) More than 15 hours following 10 consecutive hours off duty; or (ii) After being on duty for 20 hours or more following 10 consecutive hours off duty (iii) After having been on duty for 70 hours in any period of 7 consecutive days, if the motor carrier for which the driver drives does not operate every day in the week; or (iv) After having been on duty for 80 hours in any period of 8 consecutive days, if the motor carrier for which the driver drives operates every day in the week. (**2) Passenger-carrying commercial motor vehicle. The provisions of § 395.5 do not apply to any driver who is driving a passenger-carrying commercial motor vehicle in the State of Alaska. A driver who is driving a passenger-carrying commercial motor vehicle in the State of Alaska must not drive or be required or permitted to drive—** **(i) More than 15 hours following 8 consecutive hours off duty;** **(ii) After being on duty for 20 hours or more following 8 consecutive hours off duty;** **(iii) After having been on duty for 70 hours in any period of 7 consecutive days, if the motor carrier for which the driver drives does not operate every day in the week; or(iv) After having been on duty for 80 hours in any period of 8 consecutive days, if the motor carrier for which the driver drives operates every day in the week.** (3) A driver who is driving a commercial motor vehicle in the State of Alaska and who encounters adverse driving conditions (as defined in § 395.2) may drive and

Country	United States
	be permitted or required to drive a commercial motor vehicle for the period of time needed to complete the run. (i) After a property-carrying commercial motor vehicle driver completes the run, that driver must be off duty for at least 10 consecutive hours before he/she drives again; and **(ii) After a passenger-carrying commercial motor vehicle driver completes the run, that driver must be off duty for at least 8 consecutive hours before he/she drives again.** (i) State of Hawaii. The rules in § 395.8 do not apply to a driver who drives a commercial motor vehicle in the State of Hawaii, if the motor carrier who employs the driver maintains and retains for a period of 6 months accurate and true records showing— (1) The total number of hours the driver is on duty each day; and (2) The time at which the driver reports for, and is released from, duty each day. (j) Travel time— (1) When a property-carrying commercial motor vehicle driver at the direction of the motor carrier is traveling, but not driving or assuming any other responsibility to the carrier, such time must be counted as on-duty time unless the driver is afforded at least 10 consecutive hours off duty when arriving at destination, in which case he/she must be considered off duty for the entire period. **(2) When a passenger-carrying commercial motor vehicle driver at the direction of the motor carrier is traveling, but not driving or assuming any other responsibility to the carrier, such time must be counted as on-duty time unless the driver is afforded at least 8 consecutive hours off duty when arriving at destination, in which case he/she must be considered off duty for the entire period.** (k) Agricultural operations. The provisions of this part shall not apply to drivers transporting agricultural commodities or farm supplies for agricultural purposes in a State if such transportation: (1) Is limited to an area within a 100 air-mile radius from the source of the commodities or the distribution point for the farm supplies, and (2) Is conducted (except in the case of livestock feed transporters) during the planting and harvesting seasons within such State, as determined by the State. (l) Ground water well drilling operations. In the instance of a driver of a commercial motor vehicle who is used primarily in the transportation and operations of a ground water well drilling rig, any period of 7 or 8 consecutive days may end with the beginning of any off-duty period of 24 or more successive hours. (m) Construction materials and equipment. In the instance of a driver of a commercial motor vehicle who is used primarily in the transportation of construction materials and equipment, any period of 7 or 8 consecutive days may end with the beginning of any off-duty period of 24 or more successive hours. (n) Utility service vehicles. The provisions of this part shall not apply to a driver of a utility service vehicle as defined in § 395.2. (o) Property-carrying driver. A property-carrying driver is exempt from the requirements of § 395.3(a)(2) if: (1) The driver has returned to the driver's normal work reporting location and the carrier released the driver from duty at that location for the previous five duty tours the driver has worked; (2) The driver has returned to the normal work reporting location and the carrier releases the driver from duty within 16 hours after coming on duty following 10 consecutive hours off duty; and (3) The driver has not taken this exemption within the previous 6 consecutive days, except when the driver has begun a new 7- or 8-consecutive day period with the beginning of any off-duty period of 34 or more consecutive hours as allowed by § 395.3(c). (**p) Commercial motor vehicle transportation to or from a motion picture production site. A driver of a commercial motor vehicle providing transportation of property or passengers to or from a theatrical or television motion picture production site is exempt from the requirements of § 395.3(a) if the driver operates within a 100 air-mile radius of the location where the driver reports to and is released from work, ie, the normal work-**

Country	United States
	reporting location. With respect to the maximum daily hours of service, such a driver may not drive— **(1) More than 10 hours following 8 consecutive hours off duty;** **(2) For any period after having been on duty 15 hours following 8 consecutive hours off duty.** **(3) If a driver of a commercial motor vehicle providing transportation of property or passengers to or from a theatrical or television motion picture production site operates beyond a 100 air-mile radius of the normal work-reporting location, the driver is subject to § 395.3(a), and paragraphs (p)(1) and (2) of this section do not apply.** (q) Transporters of grapes during harvest period in the State of New York. The provisions of this part shall not apply to drivers transporting grapes if such transportation: (1) Is within the State of New York; (2) Is west of Interstate 81; (3) Is within a 150 air-mile radius of where the grapes were picked or distributed; and (4) Is during the harvest period as defined by the State of New York. This provision expires September 30, 2009. (r) Railroad signal employees. The provisions of this part shall not apply to a signal employee, as defined in §395.2, who operates a commercial motor vehicle, is engaged in installing, repairing, or maintaining signal systems, is employed by a railroad carrier or a contractor or subcontractor to a railroad carrier, while regulated by the Federal Railroad Administration. [57 FR 33647, July 30, 1992, as amended at 58 FR 33777, June 21, 1993; 60 FR 38748, July 28, 1995; 61 FR 14679, Apr. 3, 1996; 63 FR 33279, June 18, 1998; 68 FR 22515, Apr. 28, 2003; 68 FR 56211, Sept. 30, 2003; 70 FR 50071, Aug. 25, 2005; 72 FR 36790, July 5, 2007; 72 FR 55703, Oct. 1, 2007; 72 FR 71269, Dec. 17, 2007; 76 FR 25590, May 5, 2011]

Appendix H: Bureau of Labor Statistics

Gender

Truck Drivers

Table 147. BLS Findings for Prevalence of Gender in Truck Drivers

Year	Total Number of Drivers*	Gender Findings			
		Males		Females	
		N =	%	N =	%
2011	3,059,000	2,913,000	95.2	146,000	4.8
2010	3,028,000	2,890,000	95.4	138,000	4.6
2009	3,151,000	2,986,000	94.8	165,000	5.2
2008	3,388,000	3,221,000	95.1	167,000	4.9
2007	3,461,000	3,278,000	94.7	183,000	5.3
2006	3,475,000	3,293,000	94.8	182,000	5.2
2005	3,408,000	3,254,000	95.5	154,000	4.5
2004	3,276,000	3,129,000	95.5	147,000	4.5
2003	3,214,000	3,066,000	95.4	148,000	4.6
2002	3,364,000	3,192,000	94.9	172,000	5.1
Mean	**3,282,400**	**3,122,200**	**95.12**	**160,200**	**4.88**

*Drivers encompass the occupations of driver/sales workers, heavy and tractor-trailer drivers, and light truck or delivery service drivers. Data for heavy and tractor-trailer truck drivers could not be isolated.

Bus drivers

Table 148. BLS Findings for Prevalence of Gender in Motorcoach/bus Drivers

Year	Total Number of Drivers*	Gender Findings			
		Males		Females	
		N =	%	N =	%
2011	572,000	324,000	56.6	248,000	43.4
2010	600,000	318,000	53	282,000	47
2009	655,000	317,000	48.4	338,000	51.6
2008	651,000	332,000	51	319,000	49
2007	578,000	280,000	48.4	298,000	51.6
2006	564,000	284,000	50.4	280,000	49.6
2005	591,000	303,000	51.3	288,000	48.7
2004	602,000	310,000	51.5	292,000	48.5
2003	558,000	288,000	51.6	270,000	48.4
2002	558,000	286,000	51.3	272,000	48.7
Mean	**592,900**	**304,200**	**51.3**	**288,700**	**48.7**

*Drivers encompass the two occupations of bus drivers: 1) transit and intercity (which includes motorcoach) bus drivers, and 2) school and special client bus drivers.

Race/Ethnicity

Truck Drivers

Table 149. BLS Findings for Prevalence of Race/Ethnicity Among Truck Drivers

Year	Total Number of Drivers*	Race/Ethnicity Findings									
		White		Black		Asian		Other		Hispanic	
		N =	%	N =	%	N =	%	N =	%	N =	%
2011	3,059,000	2,530,000	82.7	419,000	13.7	50,000	1.6	61,180	2.0	538,000	17.6
2010	3,028,000	2,509,000	83.0	412,000	13.6	45,000	1.5	47,671	1.9	531,000	17.5
2009	3,151,000	2,598,000	82.5	422,000	13.4	56,000	1.8	72,473	2.3	590,000	18.7
2008	3,388,000	2,784,000	82.2	483,000	14.3	52,000	1.5	67,760	2.0	602,000	17.8
2007	3,461,000	2,862,000	82.7	477,000	13.8	49,000	1.4	72,681	2.1	604,000	17.5
2006	3,475,000	2,878,000	82.8	483,000	13.9	40,000	1.2	72,975	2.1	557,000	16.0
2005	3,408,000	2,801,000	82.2	496,000	14.5	39,000	1.1	74,976	2.2	558,000	16.4
2004	3,276,000	2,722,000	83.1	439,000	13.4	44,000	1.3	70,708	2.2	516,000	15.8
2003	3,214,000	2,676,000	83.3	411,000	12.8	53,000	1.6	73,922	2.3	481,000	15.0
2002	3,364,000	2,808,000	83.4	459,000	13.6	63,000	1.9	37,004	1.1	467,000	13.9
Mean	**3,282,400**	**2,716,800**	**82.77**	**450,100**	**13.71**	**49,100**	**1.46**	**65,135**	**1.98**	**544,400**	**16.59**

*Drivers encompass the occupations of driver/sales workers, heavy and tractor-trailer drivers, and light truck or delivery service drivers. Data for heavy and tractor-trailer truck drivers could not be isolated

Motorcoach/bus Drivers

Table 150. BLS Findings for Prevalence of Race/Ethnicity Among Motorcoach/bus Drivers

Year	Total Number of Drivers*	Race/Ethnicity Findings									
		White		Black		Asian		Other		Hispanic	
		N =	%	N =	%	N =	%	N =	%	N =	%
2011	572,000	404,000	71.0	141,000	24.6	9,000	1.6	16,016	2.8	73,000	12.7
2010	600,000	422,000	70.3	151,000	25.1	13,000	2.2	14,400	2.4	74,000	12.3
2009	655,000	463,000	70.7	163,000	24.9	13,000	2.0	15,720	2.4	87,000	13.3
2008	651,000	426,000	65.4	198,000	30.4	12,000	1.8	15,624	2.4	79,000	12.2
2007	578,000	403,000	69.7	155,000	26.8	7,000	1.2	13,294	2.3	65,000	11.2
2006	564,000	379,000	67.1	166,000	29.4	7,000	1.2	12,972	2.3	69,000	12.2
2005	591,000	431,000	72.9	137,000	23.2	8,000	1.4	14,775	2.5	75,000	12.7
2004	602,000	428,000	71.1	147,000	24.2	12,000	2.0	16,254	2.7	77,000	12.8
2003	558,000	377,000	67.7	160,000	28.7	8,000	1.4	12,834	2.3	57,000	10.2
2002	558,000	385,000	68.9	159,000	28.4	11,000	1.9	4,464	0.08	58,000	10.4
Mean	**592,900**	**411,800**	**69.45**	**157,700**	**26.59**	**10,000**	**1.68**	**13,635**	**2.28**	**71,400**	**12.04**

*Drivers encompass the occupations of driver/sales workers, heavy and tractor-trailer drivers, and light truck or delivery service drivers. Data for heavy and tractor-trailer truck drivers could not be isolated.

Age

Truck Drivers

Table 151. BLS Prevalence of Age Among Truck Drivers

Year	Total Number of Drivers	Age Findings														
		Median Age Average	16-19 Years		20-24 Years		25-34 Years		35-44 Years		45-54 Years		55-64 Years		≥65 Years	
			N=	%	N=	%	N=	%	N=	%	N=	%	N=	%	N=	%
2011	3,059,000	45.4	43,000	1.4	167,000	5.5	550,000	18.0	716,000	23.4	858,000	28	547,000	17.9	178,000	5.8
2010	3,028,000	44.8	39,000	1.3	170,000	5.6	525,000	17.3	751,000	24.8	861,000	28.4	523,000	17.3	159,000	5.3
2009	3,151,000	44.0	41,000	1.3	175,000	5.6	589,000	18.7	819,000	26.0	860,000	27.3	496,000	15.7	170,000	5.4
2008	3,388,000	43.5	40,000	1.2	213,000	6.3	640,000	18.9	906,000	26.7	891,000	26.3	524,000	15.5	174,000	5.1
2007	3,461,000	43.3	50,000	1.4	195,000	5.6	661,000	19.1	936,000	27.1	929,000	26.8	539,000	15.6	150,000	4.3
2006	3,475,000	42.7	60,000	1.7	230,000	6.6	675,000	19.4	960,000	27.6	898,000	25.8	500,000	14.4	152,000	4.4
2005	3,408,000	42.4	53,000	1.6	231,000	6.8	726,000	21.3	915,000	26.8	867,000	25.4	470,000	13.8	146,000	4.3
2004	3,276,000	42.2	55,000	1.7	216,000	6.6	696,000	21.2	925,000	28.2	791,000	24.1	466,000	14.2	128,000	3.9
2003	3,214,000	48.7	66,000	2.1	213,000	6.6	713,000	22.2	889,000	27.7	773,000	24.1	437,000	13.6	123,000	3.8
2002	3,364,000	46.0	80,000	2.4	240,000	7.1	764,000	22.7	942,000	28.0	789,000	23.4	413,000	12.3	138,000	4.1
Mean	**3,282,400**	**44.3**	**52,700**	**1.60**	**205,000**	**6.24**	**653,900**	**19.92**	**875,900**	**26.68**	**851,700**	**25.94**	**491,500**	**14.97**	**151,800**	**4.62**

Bus Drivers

Table 152. BLS Data Regarding Age Among Motorcoach/bus Drivers

Year	Total Number of Drivers	Age Findings														
		Median Age Average	16-19 Years		20-24 Years		25-34 Years		35-44 Years		45-54 Years		55-64 Years		≥65 Years	
			N=	%	N=	%	N=	%	N=	%	N=	%	N=	%	N=	%
2011	572,000	52.6	3,000	0.52	5,000	0.87	46,000	8.0	98,000	17.0	171,000	29.8	158,000	27.6	92,000	16.0
2010	600,000	51.3	3,000	0.50	8,000	1.3	58,000	9.7	130,000	21.7	173,000	28.8	144,000	24.0	84,000	14.0
2009	655,000	50.8	1,000	0.15	10,000	1.5	75,000	11.5	142,000	21.7	195,000	29.8	152,000	23.2	80,000	12.2
2008	651,000	49.4	1,000	0.15	22,000	3.4	71,000	10.9	153,000	23.5	177,000	27.2	153,000	23.5	75,000	11.5
2007	578,000	49.8	0	0	13,000	2.2	60,000	10.4	131,000	22.7	172,000	30.0	138,000	23.9	64,000	11.1
2006	564,000	49.5	2,000	0.35	9,000	1.6	70,000	12.4	139,000	24.6	165,000	29.2	125,000	22.1	55,000	9.7
2005	591,000	48.9	1,000	0.17	13,000	2.2	67,000	11.3	157,000	26.6	155,000	26.2	144,000	24.4	54,000	9.1
2004	602,000	47.6	0	0	17,000	2.8	74,000	12.3	156,000	25.9	172,000	28.6	128,000	21.3	54,000	9.0
2003	558,000	48.7	0	0	12,000	2.2	63,000	11.3	136,000	24.4	181,000	32.4	112,000	20.1	53,000	9.5
2002	558,000	46.0	1,000	0.18	13,000	2.3	85,000	15.3	160,000	28.7	155,000	27.8	102,000	18.3	41,000	7.4
Mean	**592,900**	**49.46**	**1,200**	**0.20**	**12,200**	**2.06**	**66,900**	**11.28**	**140,200**	**23.64**	**171,600**	**28.94**	**135,600**	**22.87**	**65,200**	**10.99**

Education

Truck drivers

Table 153. BLS Findings for Prevalence of Education in Truck Drivers

Year	Total Number of Drivers ≥ 25 Years	Education Findings Among Drivers ≥ 25 Years											
		Less Than H.S. Diploma		H.S. Diploma, No College		Some College		Associate Degree[1]		Bachelor's Degree		Master's Degree or Higher[1]	
		N=	%	N=	%	N=	%	N=	%	N=	%	N=	%
2011	2,849,000	427,000	15.0	1,509,000	53.0	513,000	18.0	217,000	7.6	148,000	5.2	35,000	1.2
2010	2,819,000	448,000	16.0	1,517,000	53.8	483,000	17.1	199,000	7.1	147,000	5.2	26,000	0.9
2009	2,935,000	502,000	17.1	1,575,000	53.7	494,000	16.8	181,000	6.2	151,000	5.1	32,000	1.1
2008	3,136,000	539,000	17.2	1,631,000	52.0	592,000	18.9	185,000	5.9	157,000	5.0	32,000	1.0
2007	3,215,000	568,000	17.7	1,676,000	52.1	584,000	18.2	190,000	5.9	169,000	5.3	27,000	0.8
2006	3,184,000	566,000	17.8	1,690,000	53.1	560,000	17.6	193,000	6.1	154,000	4.8	20,000	0.6
2005	3,125,000	572,000	18.3	1,688,000	54.0	536,000	17.2	183,000	5.8	117,000	3.7	27,000	0.9
2004	3,005,000	587,000	19.5	1,600,000	53.2	500,000	16.6	160,000	5.3	134,000	4.5	24,000	0.8
2003	2,935,000	602,000	20.5	1,538,000	52.4	479,000	16.3	165,000	5.6	133,000	4.5	17,000	0.4
2002	3,045,000	584,000	19.2	1,593,000	52.3	515,000	16.9	186,000	6.1	154,000	5.1	12,000	0.4
Mean	**3,024,800**	**539,500**	**17.8**	**1,601,700**	**53.0**	**525,600**	**17.9**	**185,900**	**6.2**	**146,400**	**4.9**	**25,200**	**0.8**

1 Associates degree includes occupational and academic degrees; 2 Master's degree or higher includes professional and doctoral degrees

Table 154. BLS Prevalence of Education Among Motorcoach/bus Drivers

Year	Total Number of Drivers ≥ 25 Years	Education Findings Among Drivers ≥ 25 Years											
		Less than H.S. Diploma		H.S. Diploma, No College		Some College		Associate Degree[1]		Bachelor's Degree		Master's Degree or Higher[2]	
		N=	%	N=	%	N=	%	N=	%	N=	%	N=	%
2011	565,000	41,000	7.3	293,000	51.9	123,000	21.8	51,000	9.0	47,000	8.3	11,000	2.0
2010	589,000	51,000	8.7	309,000	52.5	122,000	20.7	55,000	9.3	43,000	7.3	10,000	1.7
2009	644,000	62,000	9.6	322,000	50.0	142,000	22.0	61,000	9.4	46,000	7.1	11,000	1.7
2008	628,000	63,000	10.0	310,000	49.4	153,000	24.4	56,000	9.0	39,000	6.2	8,000	1.3
2007	564,000	52,000	9.2	300,000	53.2	133,000	23.6	41,000	7.3	32,000	5.7	6,000	1.1
2006	554,000	54,000	9.7	281,000	50.7	128,000	23.1	48,000	8.7	35,000	6.3	7,000	1.3
2005	577,000	71,000	12.3	293,000	50.8	124,000	21.5	44,000	7.6	36,000	6.2	9,000	1.6
2004	584,000	79,000	13.5	285,000	48.8	135,000	23.1	48,000	8.2	29,000	5.0	9,000	1.51
2003	546,000	68,000	12.5	278,000	50.9	123,000	22.5	37,000	6.8	34,000	6.2	6,000	1.1
2002	544,000	76,000	14.0	271,000	50.0	113,000	20.8	42,000	7.7	33,000	6.1	8,000	1.5
Mean	**579,500**	**61,700**	**10.6**	**294,200**	**50.8**	**129,600**	**22.4**	**48,300**	**8.3**	**37,400**	**6.5**	**8,500**	**1.5**

1 Includes occupational and academic degrees.

2 Includes professional and doctoral degrees