NIOSH Hazard Review

Work-Related Roadway Crashes

Challenges and Opportunities for Prevention

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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by Stephanie G. Pratt, MM, MA

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FOREWORD

Work-related roadway crashes are the leading cause of death from traumatic injuries in the U.S. workplace. They continue to exact a substantial toll on American workers, accounting for nearly 12,000 deaths between 1992 and 2000. Deaths and injuries from these roadway crashes result in increased costs to employers and lost productivity. They bring needless pain and suffering to family, friends, and coworkers.

Prevention of work-related roadway crashes poses one of the greatest challenges in occupational safety. The roadway is a unique work environment. Compared with other work settings, employers' ability to control working conditions and to exert direct supervisory controls is limited. Traffic volumes and road construction continue to increase. Workers may be pressured to drive faster and for longer periods and to use technologies that may lead to inattention to the driving task. The problem of work-related roadway crashes affects those who occasionally drive personal vehicles on the job as well as those who routinely drive commercial motor vehicles over long distances.

Despite these challenges, progress can be made in reducing the toll of work-related roadway crashes on American workers and their families. Employers, government agencies, policy makers, industry, and the research community must all work actively toward this goal. This document provides a comprehensive view of the problem. It also identifies the groups of workers at greatest risk of traffic crashes, summarizes key issues that contribute to work-related roadway crashes, and recommends preventive measures for employers and other stakeholders.

The National Institute for Occupational Safety and Health (NIOSH), as the national agency responsible for occupational safety and health research, is committed to reducing the toll of work-related roadway crashes on American workers. We look forward to continuing to work with our public- and private-sector partners who have similar interests in protecting American workers who drive on the job.

John Howard, M.D.
Director
National Institute for Occupational
Safety and Health

EXECUTIVE SUMMARY

WORK-RELATED ROADWAY CRASHES— THE SCOPE OF THE PROBLEM

In the United States, roadway crashes are the leading cause of death from unintentional injury in the general population and also in the workplace, where they accounted for 1,347 (23.5%) civilian worker deaths in 2000. This document provides an overview of current issues affecting work-related roadway crashes and focuses on preventing injuries and fatalities to vehicle drivers and passengers.

No single satisfactory source of data exists for worker injuries and fatalities resulting from vehicle-related roadway crashes. Specialized data systems for work-related fatalities may identify high proportions of cases but lack necessary detail about the circumstances and risk factors surrounding vehicle-related crashes. On the other hand, systems designed to collect information about all vehicle-related crashes contain more pertinent data elements but may not determine the work status of persons involved in crashes.

Data from the Census of Fatal Occupational Injuries (CFOI), a program of the Bureau of Labor Statistics (BLS), indicate that 11,952 work-related highway fatalities of civilian workers occurred during 1992–2000, with an average annual rate of 1.08 deaths per 100,000 full-time equivalent (FTE) workers. These fatalities increased in number by 18.7% from 1992 to 2000 and were the leading cause of occupational fatalities throughout the period.

CFOI data indicate that workers employed in the Transportation, Communications, and Public Utilities industry division,* which includes commercial trucking, were at highest risk of fatality. Those employed in Transportation and Material Moving occupations (truck drivers in particular) had far higher fatality rates than workers in any other occupation group. Fatality risk varied across age groups; workers aged 65 or older had more than three times the fatality risk of workers of all ages, and workers aged 20 or younger (who might be expected to have lower levels of exposure to vehicles in the workplace) had fatality rates that were similar to those for workers of all ages.

According to CFOI data, collisions between vehicles accounted for nearly half the fatal events, followed by noncollision events (e.g., loss of control, rollover) and collisions in which the worker's vehicle left the roadway and struck a stationary object on the roadside. Workers who were occupants of trucks accounted for 58% of all fatalities; nearly half of these were semi-truck occupants. However, crashes involving semi-trucks affect workers in vehicles that collide with semi-trucks as well as pedestrian workers. In recent years, sharp increases in the number of large trucks on the road and in the number of vehicle miles traveled by large trucks have been accompanied by an increase in the number of fatalities involving these vehicles.

*Of the Standard Industrial Classification (SIC).

Although rates of fatal crash involvement for large trucks (number of vehicles involved per 100 million vehicle miles traveled) declined from 3.8 to 2.6 between 1988 and 1992, they have shown little improvement since that time.

Concerns about motor vehicle safety in the workplace are by no means limited to those surrounding the operation of large trucks. Workers outside the motor carrier industry routinely operate company-owned vehicles for deliveries, sales and repair calls, client visits, and countless other job tasks. In these instances, the employer providing the vehicle generally plays a major role in setting safety, maintenance, and training policy. However, when a worker drives a personal vehicle for work purposes, the employer may have little or no control over vehicle maintenance and selection. The special needs of all three types of operating environments—the motor carrier industry, other vehicle fleets, and personal vehicles used for work purposes—must be considered by companies and policy makers when formulating safety policy.

FEDERAL AGENCIES RESPONSIBLE FOR MOTOR VEHICLE SAFETY IN THE WORKPLACE

A number of Federal agencies are responsible for enforcing safety regulations that affect the operation of motor vehicles in the workplace. The National Highway Traffic Safety Administration (NHTSA), housed in the U.S. Department of Transportation (DOT), holds primary responsibility for developing and enforcing minimum design and safety performance standards that apply to all vehicles manufactured for sale or use in the United States. Other DOT agencies with related responsibilities include the Federal Motor Carrier Safety Administration (FMCSA), which enforces comprehensive regulations that cover trucks and passenger vehicles in the motor carrier industry, and the Federal Highway Administration, which develops guidelines and standards for highway design and construction and temporary traffic control.

Other safety regulations enforced by the Department of Labor (DOL) also address motor vehicle operation in the workplace. The DOL's Employment Standards Administration, Wage and Hour Division, enforces child labor laws that define conditions under which workers under age 18 may operate a motor vehicle. Occupational Safety and Health Administration (OSHA) regulations covering certain industries are applicable to workers of all ages, but they primarily address the operation of mobile machinery off the highway. Other nonregulatory Federal agencies make recommendations about the safe operation of motor vehicles on the job. The National Transportation Safety Board investigates roadway crashes and develops safety recommendations directed at Federal and State agencies and other groups. The National Institute for Occupational Safety and Health (NIOSH) conducts occupational safety and health research and makes research-based recommendations for the safe operation of motor vehicles in the workplace.

ISSUES CRITICAL TO THE SAFE OPERATION OF MOTOR VEHICLES IN THE WORKPLACE

Proactive employer policy can do much to promote vehicle safety on and off the job. Employers can provide fleet vehicles that offer the highest levels of occupant protection in the event of a crash, and they can ensure that these vehicles receive regular inspection and maintenance.

Driver competence and readiness are also critical to workplace vehicle safety, thus it is crucial that employers check driving records of prospective workers, ensure that workers have valid driver's licenses, and provide training appropriate for the vehicle the worker will operate. In addition, employers should not place workers at risk by pressing them to complete deliveries or client contacts within unrealistic time frames. The single most important driver safety policy that employers can implement and enforce is the mandatory use of seat belts. NHTSA estimated that in 2000, the use of seat belts prevented 11,889 fatalities in the United States and could have prevented 9,238 fatalities that did occur [NHTSA 2002a].

Driver fatigue has been identified as a contributor to roadway crashes among workers as well as in the general population. Time of day (especially night driving), duration of wakefulness, inadequate sleep, sleep disorders, and prolonged work hours (including time spent performing nondriving tasks) have all been identified as contributing to the risk of fatigue-related crashes. The number of hours driven is of particular concern to the motor carrier industry. Effective January 4, 2004, revised FMCSA regulations applicable to property-carrying commercial motor vehicle (CMV) drivers will specify that drivers may not drive

—more than 11 hours following 10 consecutive hours *off duty*, or

—for any period of time after having been *on duty* 14 hours following 10 consecutive hours *off duty*.

Existing FMCSA regulations, which will continue to apply to motor carriers that transport passengers, specify that drivers may not drive

—more than 10 hours following 8 consecutive hours *off duty*, or

—for any period of time after having been *on duty* 15 hours following 8 consecutive hours *off duty*.

Time pressures, the limited number of parking spaces for large trucks in rest areas, and the common industry practice of paying drivers by the mile can also contribute to drivers' exceeding allowable hours of driving or continuing to drive while fatigued.

Distracted driving, the use of cell phones while driving, and the increased use of other in-vehicle technologies present other safety concerns. Little is known about the content and length of business calls made on cell phones while driving. Research among the general population suggests that hands-free devices are not necessarily a satisfactory alternative, since conducting a conversation while driving creates cognitive demands that result in measurable declines in driver performance. Other technologies such as in-vehicle Internet and on-board navigation systems place additional demands on a driver's attention. Research has yet to determine the safety consequences of using cell phones and other technologies in combination.

Young drivers may be at increased risk for crashes because they do not have enough experience to recognize, assess, and respond to hazards, and they may be willing to accept higher levels of risk. Many of the factors that increase the risk that young drivers in the general population will be involved in vehicle crashes are also present in the workplace. Young people are not only new behind the wheel, they are also new to the workplace—compounding occupational safety concerns for this population already at high risk for vehicle crashes.

Federal regulations under the Fair Labor Standards Act (FLSA) prohibit all on-the-job driving for 16-year-olds and limit the nature and amount of driving permitted for 17-year-olds. However, the FLSA does not cover workers aged 18 and older, who are still in the process of developing driving skills and gaining experience. For this group of inexperienced young adult drivers, employers should consider postponing the assignment of intensive or time-sensitive driving tasks, thereby acting in the spirit of graduated driver licensing laws that grant driving privileges incrementallly.

Normal aging is accompanied by declines in reaction time and visual acuity, reduced ability to divide attention between tasks, and increased difficulty in handling complex and unfamiliar situations. The need to accommodate older drivers is receiving increasing attention in the traffic safety community at large. As increasing numbers of Americans continue to work beyond the traditional retirement age of 65, the special needs of older drivers become a workplace safety issue as well. Employers will increasingly need to evaluate methods for giving older drivers continued opportunities for employment while ensuring that safety is not compromised. In addition, recommended highway changes designed to accommodate older drivers will benefit workers of all ages as well as the general driving population.

MEASURES FOR PREVENTING WORK-RELATED ROADWAY CRASHES

Preventing work-related roadway crashes calls for the application of knowledge from both the occupational safety community and the roadway safety community. The occupational safety community clearly needs to be involved because of its direct interest in ensuring workers' safety. The roadway safety community needs to be involved because its actions and policies affect the safety of all road users, including workers. Because the types of vehicles, operating environments, and levels of regulation associated with work-related driving are so varied, those responsible for vehicle safety on the job must select from a wide range of prevention strategies. Selected prevention measures recommended by NIOSH are listed here (see Chapter 5 for a complete list).

Employers

- Implement and enforce mandatory seat belt use policies.
- Ensure that no worker is assigned to drive on the job if he or she does not have a valid driver's license. The license should be appropriate for the type of vehicle to be driven.
- Provide fleet vehicles that offer the highest possible levels of occupant protection in the event of a crash.
- Maintain complete and accurate records of workers' driving performance. In addition to driver's license checks for prospective employees, periodic rechecks after hiring are critical.
- Incorporate fatigue management into safety programs.
- Ensure that workers receive the training necessary to operate specialized motor vehicles or equipment.

- Offer periodic screening of vision and general physical health for all workers for whom driving is a primary job duty.
- Avoid requiring workers to drive irregular hours or to extend their workday far beyond their normal working hours as a result of driving responsibilities.
- Establish schedules that allow drivers to obey speed limits and follow applicable hours-of-service regulations.
- Set safety policy in accordance with State graduated driver licensing laws so that company operations do not place younger workers in violation of these laws.
- Assign driving-related tasks to young drivers in an incremental fashion, beginning with limited driving responsibilities and ending with unrestricted assignments.

Policy Makers

- Support field studies to determine the safety consequences of revised FMCSA hours-of-service regulations that will apply to property-carrying CMV drivers beginning January 4, 2004.

Transportation Planners and Traffic Engineers

- Widen pavement markings and use road signs and traffic control devices that are large, well illuminated, well maintained, simple, and concise.
- Use directional turn arrows at busy intersections.
- Use positive barriers in crossovers and transition areas in highway construction zones.

These changes in highway design, signage, and traffic control devices will help older drivers and all other drivers.

Safety Professionals

- Incorporate information about sharing the road safely with trucks and other large commercial motor vehicles into driver education courses, State driver's manuals, and workplace driver training programs.

Workers

- Use safety belts while driving on or off the job.
- Avoid placing or taking cell phone calls while operating a motor vehicle, especially in inclement weather, unfamiliar areas, or heavy traffic.
- Avoid other activities such as eating, drinking, or adjusting noncritical vehicle controls while driving.

PUBLIC HEALTH SUMMARY

What are the hazards?

Work-related roadway crashes continue to be the leading cause of injury fatalities for workers in the United States. In 2000, roadway crashes killed 1,347 civilian workers and accounted for more than 23% of all workplace fatalities. Although other workplace fatalities have declined in recent years, the number of deaths from roadway crashes increased steadily from 1,135 in 1992 to 1,471 in 1999. In 2000, they decreased to 1,347.

How are workers exposed or put at risk?

In 2000, more than 5.8 million workers were employed in Transportation and Material Moving occupations. More than 4.4 million of these workers were motor vehicle operators, of whom 77% were truck drivers. In addition to these 4.4 million workers whose primary job duty is to operate a motor vehicle, numerous other workers operate motor vehicles as part of their job duties. Some operate fleet vehicles provided by their employers, and others drive personal vehicles while performing their jobs.

What agencies within the Federal government make recommendations related to vehicle safety in the workplace?

Two Federal agencies in the U.S. Department of Transportation (DOT)—the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA)—hold primary responsibility for developing and enforcing vehicle safety standards. FMCSA standards cover commercial motor carriers, whereas NHTSA regulations set forth design and performance requirements for vehicle manufacturers. The Federal Highway Administration, another agency in the U.S. DOT, develops guidelines and standards for highway design and construction and temporary traffic control. The programs of this agency affect the safety of all road users, including workers who drive on the job. Two agencies within the U.S. Department of Labor (DOL) have regulatory responsibilities that affect worker safety. The Employment Standards Administration enforces the child labor provisions of the Fair Labor Standards Act (FLSA), and the Occupational Safety and Health Administration (OSHA) has regulations for certain industries that primarily address operation of machinery and equipment off the highway. Two other Federal agencies with interest in vehicle safety are engaged primarily in research and investigative activities. The National Transportation Safety Board investigates roadway crashes and develops safety recommendations directed at Federal and State agencies and other groups. The National Institute for Occupational Safety and Health (NIOSH) is charged with conducting occupational safety and health research and makes research-based recommendations for the safe operation of motor vehicles in the workplace.

Where is more information available?

The references, additional readings, and online resources cited at the end of this document identify sources that provide more information about work-related roadway crashes. Additional information may also be obtained from NIOSH at **www.cdc.gov/niosh**. Or call NIOSH at 1-800-35-NIOSH (1–800–356–4674).

ABBREVIATIONS

BLS	Bureau of Labor Statistics
BOC	Bureau of the Census
CDL	commercial driver's license
CDS	Crashworthiness Data System
CFOI	Census of Fatal Occupational Injuries
CFR	Code of Federal Regulations
CMV	commercial motor vehicle
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
FARS	Fatality Analysis Reporting System
FLSA	Fair Labor Standards Act
FMCSA	Federal Motor Carrier Safety Administration
FTE	full-time equivalent [worker]
GES	General Estimates System
GVWR	gross vehicle weight rating
Hz	hertz
kg	kilogram
n	number (sample size)
n.e.c.	not elsewhere classified
NHTSA	National Highway Traffic Safety Administration
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
SIC	Standard Industrial Classification
SOII	Survey of Occupational Injuries and Illnesses
TCPU	Transportation, Communications, and Public Utilities
TIFA	Trucks Involved in Fatal Accidents
U.S.	United States

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1 INTRODUCTION

In the United States, roadway crashes* are the leading cause of death from unintentional injury in the general population. In 2000, roadway crashes killed 36,249 vehicle drivers and passengers and injured nearly 3.1 million [NHTSA 2001a]. Roadway crashes were also the leading contributor to occupational injury fatalities, accounting for 1,347 civilian worker deaths (23.5%) in 2000.

Roadway crashes were the leading contributor to occupational injury fatalities in 2000.

In 2000, the total cost of motor vehicle crashes, occupational and nonoccupational, was estimated by the National Highway Traffic Safety Administration (NHTSA) to be $230.6 billion [NHTSA 2002a]. This figure represents a substantial increase over the NHTSA estimate of $150.5 billion published in 1996 [NHTSA 1996]. Costs in 2000 related to lost wages and benefits for crash victims totaled $61 billion, or 26% of the total. Workplace costs associated with disruptions because of the loss or absence of an employee accounted for an additional $4.6 billion, or 2% of total costs [NHTSA 2002a]. In addition to direct workplace costs, employers and injured workers and their families bear some of the costs associated with medical care, legal services, administration of insurance claims, travel delays, and repair or replacement of damaged vehicles.

The extent to which workers drive or ride in motor vehicles as part of their job duties is largely unknown, but it can be assumed that exposures are greater in some occupations and industries. Work situations involving motor vehicle operation range from those that are heavily regulated to those in which the employer may have limited influence. For certain occupations—truck drivers, taxi drivers, and bus drivers, for example—motor vehicle operation is the primary job duty. Truck and passenger vehicles in the motor carrier industry are covered by comprehensive regulations enforced by the Federal Motor Carrier Safety Administration (FMCSA), whose primary mission is ensuring safe operation within the industry. Workers in other occupations routinely operate company-owned vehicles

*The terms "roadway" and "highway" both denote any public thoroughfare, regardless of size or traffic volume. The term "roadway" is used in this document except when referring to data from the Bureau of Labor Statistics (BLS), which uses the term "highway."

The term "crash" includes the following: (1) a collision between vehicles, (2) contact of a vehicle with a stationary object such as a tree or a guardrail, and (3) a vehicle-related event that may injure or kill the occupants but does not involve contact with another vehicle or object (for example, a rollover or loss of control).

for deliveries, sales and repair calls, client visits, and countless other job tasks. In these instances, the employer providing the vehicle generally plays a major role in setting safety, maintenance, and training policy. The work situation in which the employer has the least control over motor vehicle operation is one in which a worker drives a personal vehicle for work purposes. Here, the employer may have less opportunity to influence worker safety, since the employer has little or no control over the selection and maintenance of these vehicles.

Prevention of work-related roadway crashes presents daunting challenges to employers, injury prevention and safety professionals, and government agencies responsible for roadway safety and occupational safety. The roadway is a work environment unlike any other. Employers and workers are affected by external events and environmental changes to a far greater extent than in more closed work settings where the employer can exert substantial control over the work environment. To ensure worker safety on the roadway, employers must continually readjust operational plans and safety policy in response to events largely beyond their control, such as long-term roadway construction projects, changes in traffic laws, changing market and customer demands that bring about changes in transportation patterns and volumes, and changes in government regulations. A single employer may have workers operating many different types of motor vehicles, each requiring different levels of training, maintenance, and recordkeeping.

The roadway is a work environment unlike any other.

Injury prevention and safety professionals must also look beyond their usual boundaries if they are to develop effective methods for preventing work-related roadway crashes. In some work settings, there are widely accepted interventions that will prevent injury if they are implemented properly. Examples are control of hazardous energy and fall protection. In contrast, the roadway work setting requires safety professionals to consider issues and prevention modes that apply to the broader roadway safety environment (e.g., roadway design, restraint use, and vehicle crashworthiness). This creates both challenges and opportunities for prevention. Challenges exist because the complexities increase when viewing the problem from both an occupational safety perspective and a broad roadway safety perspective. However, the situation offers the opportunity to borrow from the roadway safety community at large: what works for the general population may also work in the occupational setting. Likewise, the work of occupational safety professionals can contribute to the prevention of all roadway fatalities.

The purpose of this document is to provide an overview of current issues affecting work-related roadway crashes with a focus on preventing injuries and fatalities to vehicle drivers and passengers. Fatalities and injuries to pedestrian workers are not within the scope of this document, nor are events occurring at locations such as parking lots and industrial sites away from public roadways. The document begins by illustrating the scope and nature of the problem and presenting data on both fatal and nonfatal injuries. The next section summarizes the large body of regulations that apply to the operation of motor vehicles. Some are specific to work-related driving, and others apply to all drivers or all vehicles. The sections that follow address special topics critical to the formulation of strategies to prevent work-related roadway fatalities and injuries. These topics include driver fatigue, special issues regarding the motor carrier industry, driver distraction and cell phone use, age-related factors, and general fleet safety issues. Following the discussions of special topics are detailed strategies for preventing work-related roadway crashes. The document concludes with lists of additional readings and vehicle-related Internet resources from government agencies, research organizations, industry, and citizen groups.

2 DATA ON WORK-RELATED ROADWAY CRASHES

2.1 SOURCES OF DATA

No single satisfactory source of data exists for worker injuries and fatalities resulting from work-related roadway crashes. Specialized data systems for work-related fatalities may capture high proportions of cases yet lack the necessary details about circumstances and risk factors surrounding work-related roadway crashes. On the other hand, systems designed to collect information about all roadway crashes may contain more relevant data but may fail to determine the work status of the crash victims.

The Census of Fatal Occupational Injuries (CFOI), a program of the Bureau of Labor Statistics (BLS), is a widely used source of data on occupational fatalities in the United States. CFOI identifies high-risk demographic and industry/occupation groups, and it includes a case narrative. However, since it was designed to accommodate all types of occupational fatalities, CFOI does not contain sufficient detail on work-related roadway crashes. A primary source of data on nonfatal injuries to workers is the annual Survey of Occupational Injuries and Illnesses (SOII) (another BLS data system), which produces national injury estimates and rates from a sample survey of business establishments. The SOII data provide case counts by industry, occupation, source of injury, nature of injury, part of body affected, and type of event. However, they contain neither case narratives for individual injury incidents nor information about risk factors or circumstances.

These BLS data sources specific to occupational injuries and fatalities may be supplemented by U.S. Department of Transportation (DOT) sources: the National Automotive Sampling System (which consists of the General Estimates System [GES] and the Crashworthiness Data System) and the Fatality Analysis Reporting System (FARS). These DOT data systems are designed specifically to capture information about crashes that occur in traffic. They offer a variety of valuable data elements, including crash mechanism, vehicle characteristics, manner of collision, environmental conditions, and driver risk factors. However, they do not always note whether a worker was involved, nor do they record employment information such as occupation or industry for workers who are identified.

To take advantage of the strengths of each type of data system—work-related and vehicle-related—this report presents information from both. Presented first are data on all work-related crashes from the CFOI and SOII. These data are followed by more detailed information about crashes related to large trucks. This information was taken from CFOI, DOT data systems, and other sources.

2.2 FATAL INJURIES TO WORKERS

CFOI is a multiple-source surveillance system that draws on administrative documents from Federal and State agencies (e.g., death certificates, medical examiner records, workers' compensation reports, and regulatory agency reports) as well as media reports and followup questionnaires to employers and other informants as needed. CFOI defines a fatal work-related crash as one that occurs while the decedent is a driver or passenger in a motor vehicle for work purposes; incidents are excluded if they occur during a commute to or from work. CFOI data that appear in this report were extracted from a special research file prepared for the National Institute for Occupational Safety and Health (NIOSH). This file excludes data from New York City.* To accommodate the employment data used to calculate fatality rates, military personnel and volunteer workers were excluded from the tabulations that follow.

Data from CFOI indicate that 11,952 work-related highway fatalities† of civilian workers occurred during 1992–2000, with an average annual rate of 1.08 deaths per 100,000 full-time equivalent (FTE) workers (Table 1). These fatalities increased in number by 18.7% from 1992 to 2000 and were the leading cause of occupational fatalities throughout the period. Death rates from work-related highway fatalities increased from 0.99 to 1.13 between 1992 and 1999, declining to 1.02 in 2000.

2.2.1 Source of Injury

For vehicle collisions, CFOI defines the primary source of injury as the vehicle occupied by the worker who died. The secondary source may be the vehicle that struck or was struck by the worker's vehicle; it may also be an object such as a tree or guardrail. In many single-vehicle crashes, no secondary source exists. Semi-trucks were the leading primary vehicle

Semi-trucks were the leading primary vehicle source of fatalities to workers during 1992–2000.

*New York City declined to authorize inclusion of its data in the special research file prepared for NIOSH.

†BLS uses the term "highway" instead of "roadway" to denote any public thoroughfare, regardless of size or traffic volume.

Table 1. Work-related highway fatalities of civilian workers by year, 1992–2000

Year	Number	%*	Rate/100,000 FTEs†
1992	1,135	9.5	0.99
1993	1,221	10.2	1.03
1994	1,327	11.1	1.12
1995	1,314	11.0	1.10
1996	1,333	11.2	1.10
1997	1,373	11.5	1.09
1998	1,431	12.0	1.13
1999	1,471	12.3	1.13
2000	1,347	11.3	1.02
Total	11,952	100.0	1.08

Source: CFOI special research file (excludes New York City).
*Percentages may not add to 100 because of rounding.
†Full-time equivalent workers aged 15 or older (employment data from Current Population Survey). Employment data were not available for persons under age 15.

source (n=3,378, 28.3%) of fatalities to workers during 1992–2000 (Table 2). Automobiles were second to semi-trucks (n=2,881, 24.1%), and pickup trucks (n=1,397, 11.7%) ranked third as the primary vehicle source (Table 2).

CFOI classifies the secondary source of injury as the object that generated the source of injury or was related to the event. No secondary source was recorded for 26.2% of the fatalities. For those events in which a secondary source was recorded, more than 20% of the sources were objects other than vehicles. Of these, trees (6.0%), guardrails (4.6%), towers/poles (2.3%), and bridges (2.2%) were the most frequently struck objects. For those events in which a vehicle was the secondary source, semi-trucks (14.9%), automobiles (12.6%), and pickup trucks (5.1%) were the leading vehicle categories (Table 3). When events involved two vehicles and semi-trucks were the primary source, semi-trucks were also most likely to be the secondary source. Similarly, when automobiles were the primary source, they were also most likely to be the secondary vehicle (data not shown in table).

2.2.2 Type of Event

More than 49% (n=5,877) of the work-related highway fatalities during 1992–2000 were collisions between vehicles.

More than 49% (n=5,877) of the work-related highway fatalities during 1992–2000 were collisions between vehicles (Figure 1). The second most frequent event type resulting in a worker death was a highway noncollision incident (e.g., loss of control, rollover) (n=3,160, 26.4%), followed by a vehicle leaving the highway and striking a stationary object along the roadside (n=2,106, 17.6%). In a small number of incidents, the vehicle

Table 2. Work-related highway fatalities by primary source of injury,* 1992–2000

Primary source of injury	Number	%†
Truck	6,884	57.6
Semi-truck	3,378	28.3
Pickup truck	1,397	11.7
Unspecified truck	820	6.9
Truck, not elsewhere classified	715	6.0
Delivery truck	325	2.7
Dump truck	249	2.1
Automobile	2,881	24.1
Van—passenger or light delivery	748	6.3
Highway vehicle, unspecified	642	5.4
Offroad or industrial vehicle	318	2.7
Other highway vehicle	284	2.4
Machinery	157	1.3
All other	38	0.3
Total	11,952	100.0

Source: CFOI special research file (excludes New York City).
*CFOI defines primary source of injury as the vehicle occupied by the worker who died.
†Percentages may not add to 100 because of rounding.

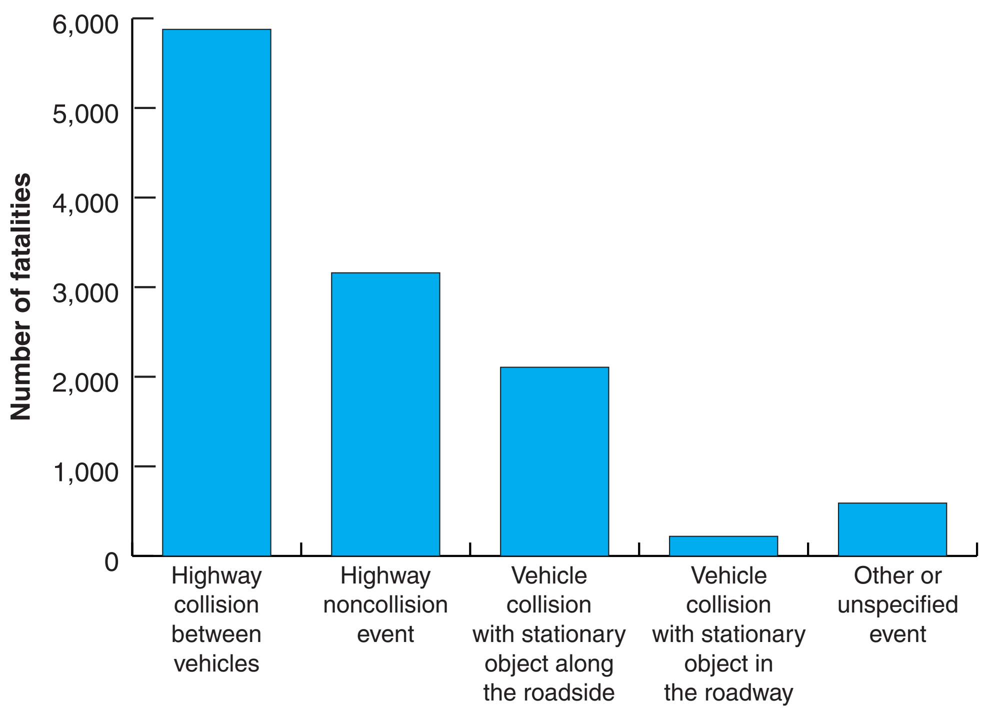

Figure 1. Work-related highway fatalities by type of event, 1992–2000. (Source: CFOI special research file [excludes New York City].)

Table 3. Work-related highway fatalities by secondary source of injury,* 1992–2000

Secondary source of injury	Number	%†
Truck	3,288	27.5
Semi-truck	1,781	14.9
Pickup truck	611	5.1
Unspecified truck	376	3.1
Truck, not elsewhere classified	258	2.2
Dump truck	196	1.6
Delivery truck	66	0.6
Automobile	1,508	12.6
Highway vehicle, unspecified	609	5.1
Van—passenger or light delivery	239	2.0
All other vehicles	170	1.4
Object other than vehicle	2,653	22.2
Tree	719	6.0
Guardrail or road divider	552	4.6
Tower or pole	279	2.3
Bridge, dam, or lock	266	2.2
Other	837	7.0
All other secondary sources	355	3.0
No secondary source	3,130	26.2
Total	14,605	100.0

Source: CFOI special research file (excludes New York City).
*CFOI defines secondary source of injury as the vehicle that struck or was struck by the worker's vehicle; it may also be an object such as a tree or guardrail.
†Percentages may not add to 100 because of rounding.

struck an object or other obstruction in the roadway—such as a box, log, or traffic control device (n=219, 1.8%). Noncollisions were the most common type of event found among semi-trucks (n=1,202, 35.6%), whereas collisions between vehicles were by far the most frequent type of event among automobiles (n=1,931, 67.0%).

2.2.3 Geographic Distribution

CFOI records whether a crash occurred in an urban area (defined by CFOI as being part of a metropolitan statistical area) or a rural area (defined by CFOI as being outside a metropolitan statistical area). Between 1992 and

2000, 54.8% of the fatal work-related highway crashes occurred within urban areas, and 44.0% occurred in rural areas. Urban or rural location was not reported for the remaining crashes. Trucks of all types accounted for 64.9% of all fatal rural crashes and 52.1% of fatal urban crashes. Semi-trucks were slightly more likely to be involved in fatal events in rural areas than in urban areas (52.4% versus 46.8%). In contrast, fatalities to automobile occupants were much more likely to occur in urban areas (63.5% versus 34.6%).

In 1994, CFOI began collecting information about the type of roadway on which a crash occurred. Between 1994 and 2000, more work-related highway fatalities occurred on State and U.S. highways than on any other type of specified roadway (n=3,608, 37.6%) (Table 4). Interstates and freeways accounted for 25.8% of all work-related highway fatalities, and local roads and streets accounted for 24.2%. For most vehicle types, State and U.S. highways were the most frequent type of road on which a crash occurred. Two exceptions were semi-trucks, for which interstate highways were the predominant road type (43.1%), and “all other” vehicles, for which the highest proportion of fatalities occurred on local streets (38.6%). Although fatal automobile crashes most often took place on State and U.S. highways (36.7%), 31.8% occurred on local streets. In contrast, only 8.5% of fatal semi-truck crashes occurred on local streets.

Between 1994 and 2000, more work-related highway fatalities occurred on State and U.S. highways than on any other type of specified roadway.

Table 4. Work-related highway fatalities by primary source of injury on various types of roadways, 1994–2000*

Type of roadway	Primary source of injury†													
	Semi-truck		Pickup truck		Other/ unspecified truck		Automobile		Van		All other		Total	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
State or U.S. highway	1,111	40.0	492	42.1	623	36.7	809	36.7	237	37.3	336	30.4	3,608	37.6
Interstate/ freeway	1,198	43.1	222	19.0	345	20.3	370	16.8	202	31.8	139	12.6	2,476	25.8
Local street	237	8.5	311	26.6	490	28.9	702	31.8	156	24.6	427	38.6	2,323	24.2
Other/ unspecified street or highway; other location	235	8.5	145	12.4	240	14.1	325	14.7	40	6.3	204	18.4	1,189	12.4
Total	2,781	29.0	1,170	12.2	1,698	17.7	2,206	23.0	635	6.6	1,106	11.5	9,596	100.0

Source: CFOI special research file (excludes New York City).
*Percentages may not add to 100 because of rounding.
†CFOI defines primary source of injury as the vehicle occupied by the worker who died.

2.2.4 Time of Incident

For semi-truck occupants, higher proportions of fatalities occurred between 3 a.m. and 7 a.m., and the greatest number of deaths occurred at the 5 a.m. hour.

For all work-related fatalities on the highway, the greatest numbers of crashes occurred between the daytime work hours of 7 a.m. and 4 p.m. (Figure 2). Fatalities of automobile occupants followed a similar pattern (Figure 3). In contrast, the fatality distribution for semi-truck occupants was slightly skewed, with higher proportions of fatalities between 3 a.m. and 7 a.m., and the greatest number of deaths occurring during the 5 a.m. hour (that is, between 4:30 and 5:29 a.m.) (Figure 4).

At all hours of the day, highway collisions between vehicles were the most common type of fatal event (Figure 5). Between 8 a.m. and 4 p.m., the proportion of fatalities attributable to these collisions ranged from 51% to 58%, with 23% to 27% attributable to noncollision events. In the late evening and early morning hours, however, the contribution of collisions decreased, and the contribution of noncollision events increased. Events in which a vehicle struck a stationary object on the roadside accounted for 17.6% of all fatalities but accounted for 24% to 28% of fatalities between the hours of 11 p.m. and 6 a.m.

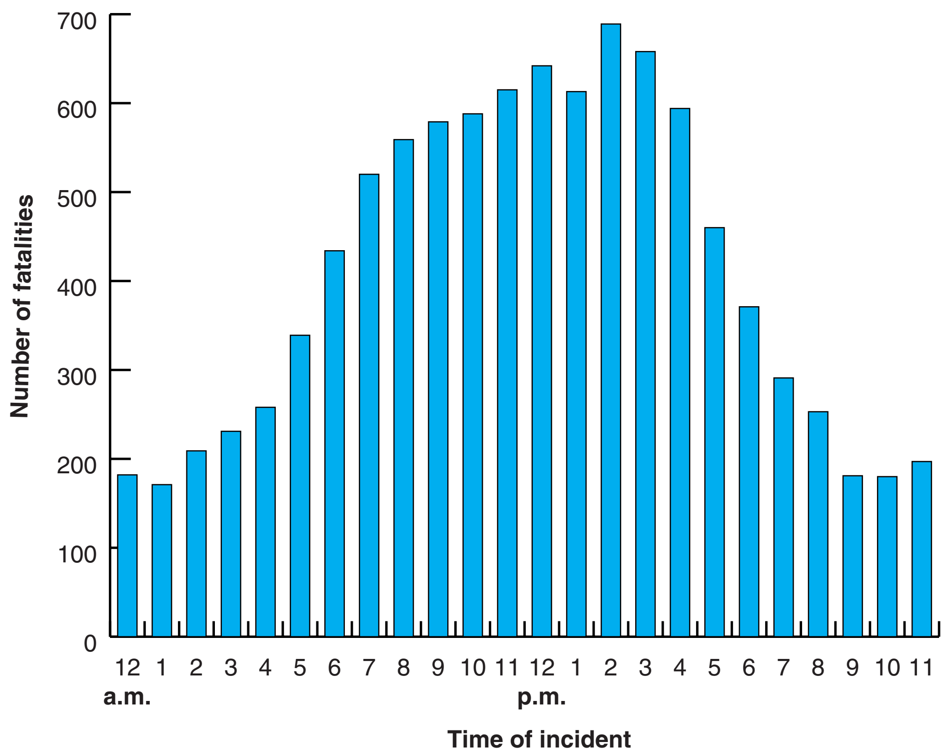

Figure 2. Work-related highway fatalities by time of incident, 1992–2000. Excludes 2,138 cases with missing data for time of incident. (Source: CFOI special research file [excludes New York City].)

2.2.5 Industry Division

CFOI classifies cases by the industry in which the decedent was employed, using the 1987 Standard Industrial Classification (SIC) [OMB 1987]. Between 1992 and 2000, the industry division with the highest number of fatalities from work-related roadway crashes was Transportation, Communications, and Public Utilities (TCPU) (n=3,893, 32.6%) (Table 5). This industry division includes transportation by rail, water, air, truck, taxicab, or bus as well as companies that provide telephone, gas, water, refuse, or electric services. This industry division had more than twice the number of fatalities reported in Services, which covers diverse industry sectors such as health care, education, business services, and auto repair (n=1,698, 14.2%). The highest vehicle-related fatality rate (4.64/100,000 FTEs) was also found in the TCPU industry division. Although the overall frequencies were comparatively low for Mining (which includes oil and gas extraction) and Agriculture, Forestry, and Fishing, these two industry divisions had the second and third highest fatality rates, respectively (3.24/100,000 FTEs and 2.58/100,000 FTEs).

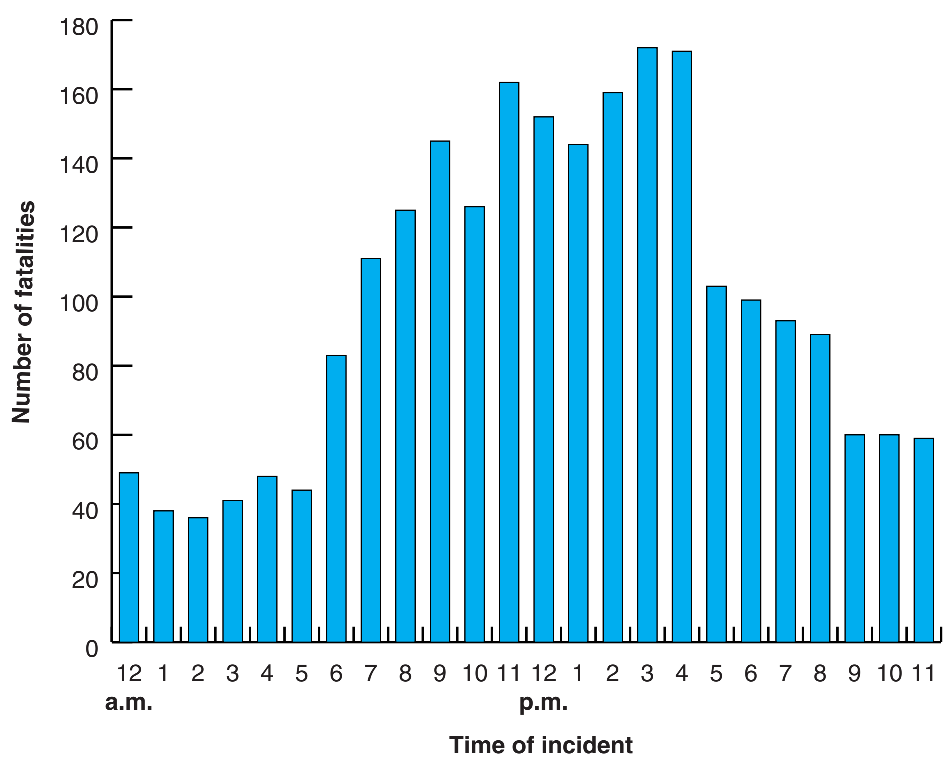

Figure 3. Work-related highway fatalities among automobile occupants by time of incident, 1992–2000. Excludes 512 cases with missing data for time of incident. (Source: CFOI special research file [excludes New York City].)

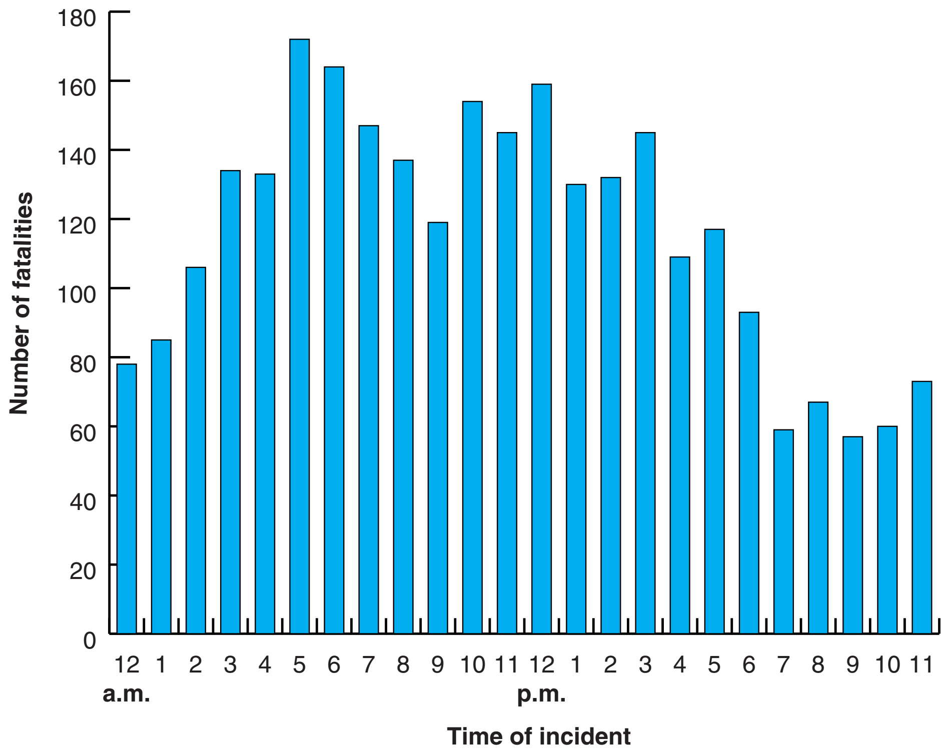

Figure 4. Work-related highway fatalities among semi-truck occupants by time of incident, 1992–2000. Excludes 603 cases with missing data for time of incident. (Source: CFOI special research file [excludes New York City].)

Table 5. Work-related highway fatalities by industry division, 1992–2000

Industry division (SIC)	Number	%	Rate/100,000 FTEs*
TCPU	3,893	32.6	4.64
Services	1,698	14.2	0.46
Construction	1,244	10.4	1.71
Manufacturing	987	8.3	0.51
Retail Trade	928	7.8	0.54
Public Administration	925	7.7	1.77
Agriculture, Forestry, and Fishing	860	7.2	2.58
Wholesale Trade	848	7.1	1.78
Finance, Insurance, and Real Estate	240	2.0	0.33
Mining	208	1.7	3.24
Unclassified	121	1.0	—
Total	11,952	100.0	1.08

Source: CFOI special research file (excludes New York City).
*Full-time equivalent workers aged 15 or older (employment data from Current Population Survey). Employment data were not available for persons under age 15.

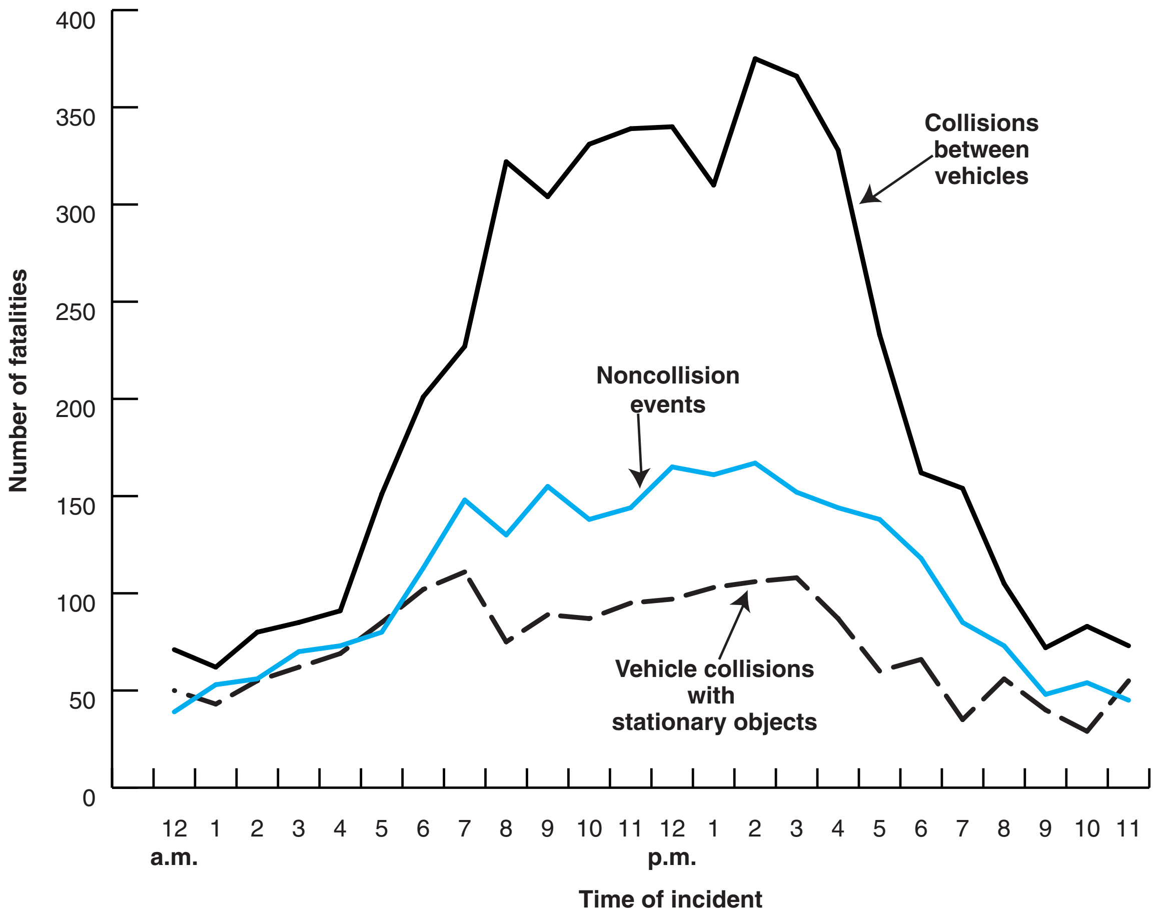

Figure 5. Work-related highway fatalities attributable to collisions between vehicles, noncollisions, and vehicle collisions with stationary objects, by time of incident, 1992–2000. Excludes 1,965 cases with missing data for time of incident. (Source: CFOI special research file [excludes New York City].)

The types of vehicles occupied by workers who died in highway crashes varied by industry division. Most of the worker fatalities within the TCPU industry division were attributed to semi-trucks (n=2,509, 74.3%). For Mining, 37.5% of the primary source vehicles were pickup trucks. Off-road and industrial vehicles, including farm tractors, contributed 30.2% of the vehicular deaths in Agriculture, Forestry, and Fishing. Three industry divisions had high proportions of fatalities in which the automobile was the primary source of injury—Finance, Insurance, and Real Estate (65.0%); Public Administration (58.2%); and Services (47.5%). For more detailed descriptions of the SIC industry divisions used in this document, see Appendix A.

2.2.6 Occupation Group

CFOI classifies worker occupation using Bureau of the Census (BOC) codes developed for the 1990 U.S. Census [BOC 1992]. Workers in Transportation and Material Moving occupations had the highest rates of vehicle-related highway fatalities among occupation groups (11.11/100,000 FTEs), 4.6 times the rate of persons in Farming, Forestry, and Fishing occupations (2.44/100,000 FTEs) (Table 6). Truck drivers, who are included among Transportation and Material Moving occupations, experienced 17.77 deaths/100,000 FTEs, a rate that is considerably higher than that for this occupation group as a whole. For more detailed descriptions of the BOC occupation groups used in this document, see Appendix B.

2.2.7 Age of Victim

Between 1992 and 2000, the largest number of work-related fatalities in roadway crashes was among workers aged 35 to 44 (n=2,940, 24.6%). However, the highest rate occurred among workers aged 65 and older. This rate (3.77/100,000 FTEs) was 2.3 times the rate for the next leading age group (workers aged 55 to 64) (Table 7).

Table 6. Work-related highway fatalities by occupation group, 1992–2000

Occupation group [BOC]	Number	%	Rate/100,000 FTEs*
Transportation and Material Moving	5,562	46.5	11.11
Truck Drivers	4,834	40.4	17.77
Precision Production, Craft, and Repair	1,058	8.9	0.82
Sales	886	7.4	0.67
Services	863	7.2	0.65
Executive, Administrative, and Managerial	817	6.8	0.47
Farming, Forestry, and Fishing	811	6.8	2.44
Professional Specialty	651	5.5	0.40
Laborer	540	4.5	1.32
Clerical	337	2.8	0.23
Technicians and Related Support	217	1.8	0.60
Operatives	115	1.0	0.17
Unclassified	95	0.8	—
Total	11,952	100.0	1.08

Source: CFOI special research file (excludes New York City).
*Full-time equivalent workers aged 15 or older (employment data from Current Population Survey). Employment data were not available for persons under age 15.

Table 7. Work-related highway fatalities by age group, 1992–2000

Age group (years)	Number	%*	Rate/100,000 FTEs†	% change in number of deaths from 1992 to 2000
< 15	30	0.3	—	—
15–19	326	2.7	0.86	32.3
20–24	873	7.3	0.85	11.1
25–34	2,597	21.7	0.90	10.1
35–44	2,940	24.6	0.93	19.7
45–54	2,586	21.6	1.12	44.7
55–64	1,687	14.1	1.64	38.9
65+	887	7.4	3.77	16.5
Unknown	26	0.2	—	—
Total	11,952	100.0	1.08	18.7

Source: CFOI special research file (excludes New York City).
*Percentages may not add to 100 because of rounding.
†Full-time equivalent workers aged 15 or older (employment data from Current Population Survey). Employment data were not available for persons under age 15.

Table 7 also demonstrates that much of the overall 18.7% increase in work-related highway fatalities was borne by adult workers. Over the 9-year period, a 44.7% increase occurred in the number of fatalities among workers aged 45 to 54, and a 38.9% increase occurred among workers aged 55 to 64. Workers aged 15 to 19 experienced a 32.3% increase. Increases were smallest among younger adult workers aged 20 to 34 and among workers aged 65 and older.

2.2.7.1 Young Workers

Table 8 displays age-specific frequencies and rates of work-related highway fatalities among young workers. Between 1992 and 2000, work-related highway incidents were the leading cause of occupational fatalities among persons aged 15 to 19, accounting for 22.9% of occupational fatalities in this age group.

The majority of work-related highway fatalities among workers aged 15 to 19 occurred within three industry divisions: Retail Trade (n=77, 23.6%), Construction (n=63, 19.3%), and Agriculture, Forestry, and Fishing (n=50, 15.3%). The young victims of these incidents were most often employed in Transportation and Material Moving occupations (n=85, 26.1%), as Laborers (n=59, 18.1%), and in Farming, Forestry, and Fishing occupations (n=53, 16.3%).

Table 8. Frequency and rate of work-related highway fatalities for workers aged 15 to 19, 1992–2000

Worker age (years)	Number of fatalities	%	Rate/100,000 FTEs*
15	12	3.7	0.85
16	32	9.8	0.77
17	45	13.8	0.66
18	110	33.7	1.03
19	127	39.0	0.86
Total	326	100.0	0.86

Source: CFOI special research file (excludes New York City).
*Full-time equivalent workers (employment data from Current Population Survey). Employment data were not available for persons under age 15.

For 73.7% of the youth fatalities (n=239), the primary source of injury was something other than an automobile: 119 were trucks, 68 of which were identified as pickup trucks. In 72.7% (n=237) of the incidents, the fatally injured youth was driving. Compared with workers of all ages, young workers were slightly less often involved in collisions between vehicles (45.7% versus 49.2% for workers of all ages), but they were more often involved in noncollisions (32.8% versus 26.4% for workers of all ages). Most of the incidents among workers aged 15 to 19 occurred between 7 a.m. and 7 p.m. (225 of the 275 cases for which time of incident was reported).

2.2.7.2 Older Workers

Workers aged 65 and older had the highest rate of work-related highway fatalities between 1992 and 2000.

Workers aged 65 and older had the highest rate of work-related highway fatalities between 1992 and 2000—more than twice that of workers aged 55 to 64 and 3.5 times the rate for workers of all ages (see Table 7). Employment and event characteristics for older workers who died in highway crashes differed in some respects from those for workers of all ages. Although the highest proportion of older worker fatalities (22.7%) occurred in the TCPU industry division, this proportion was somewhat lower than the 32.6% seen among workers of all ages. Crash victims aged 65 and older were more than twice as likely to be employed in the Agriculture, Forestry, and Fishing industry division (19.5% versus 7.2% for workers of all ages). Agricultural employment was particularly common among crash victims aged 75 or older: 29.3% compared with 16.5% for crash victims aged 65 to 74. Surprisingly high proportions of older crash victims were employed in Transportation and Material Moving occupations: 43.7% of workers aged 65 to 74 and 29.8% of those aged 75 or older, compared with 46.5% for workers of all ages.

Older workers who died in highway crashes were less likely than workers of all ages to be truck occupants (42.5% versus 57.6% for workers of all ages) and more likely to be automobile occupants (29.8% versus 24.1% for workers of all ages). Only 3.8% of semi-truck occupants who died in highway crashes were aged 65 or older, and only 0.5% were aged 75 or older. The great majority of fatalities of semi-truck occupants (more than 91%), occurred among younger adult workers aged 25 to 64.

Crash victims aged 65 or older were slightly more likely than workers of all ages to have been driving the vehicle at the time of the crash (90.0% versus 87.4%). The proportion of those who were driving did not decrease at age 75 and older. Compared with workers of all ages, older crash victims were more likely to be involved in a collision between vehicles (58.0% versus 49.2% for workers of all ages), and less likely to be involved in a noncollision event (22.9% versus 26.4% for workers of all ages). From 1994 to 2000, fatal crashes among older workers occurred less frequently on interstate highways or freeways (18.8%) than in the general worker population (25.8%).

2.2.8 Sex

The majority of work-related highway fatalities occurred among male workers (n=10,714, 89.6%), who accounted for most of the increase in frequency between 1992 and 2000 (Figure 6). For the 9-year period, the average annual vehicle-related fatality rate for male workers was six times that for female workers (1.66/100,000 FTEs versus 0.27/100,000 FTEs). However, these events accounted for proportionally more of the total occupational fatalities among female workers (29.1%) than among male workers (21.6%).

2.2.9 Worker Activity

The vast majority of work-related highway fatalities occurred among workers whose primary activity at the time of the incident was driving (n=10,440, 87.3%). An additional 10.9% (n=1,302) were workers riding in a vehicle. Some other occupant status was reported for 210 victims (1.8%). The highest proportions of workers who died while driving versus riding were in semi-trucks (93.7% versus 5.6%) and automobiles (89.5% versus 9.3%). For vans, a smaller discrepancy existed between the proportions driving (77.1%) versus riding (22.2%). Overall, male workers were nearly twice as likely as female workers to be driving versus riding (Table 9).

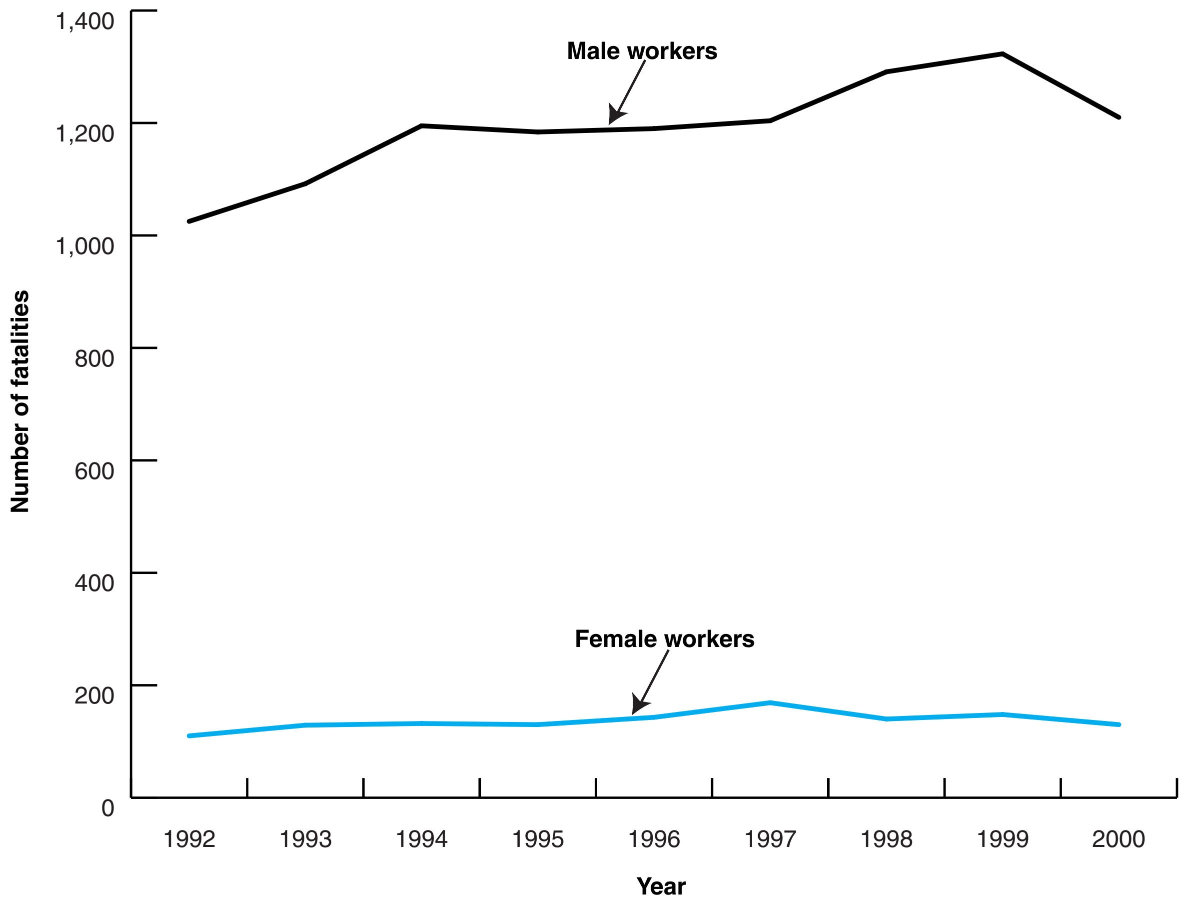

Figure 6. Work-related highway fatalities by sex, 1992–2000. (Source: CFOI special research file [excludes New York City].)

Table 9. Work-related highway fatalities by vehicle occupant status and sex, 1992–2000

Sex of occupant	Number driving	Number riding	Ratio of drivers to riders
Male	9,439	1,079	8.7
Female	1,001	223	4.5

Source: CFOI special research file (excludes New York City). Excludes 210 cases with some other occupant status reported.

2.2.10 Race

The majority of the work-related highway fatalities occurred among white workers (n=10,177, 85.1%), but the fatality rates were similar for white and black workers (1.08/100,000 FTEs versus 1.04/100,000 FTEs). For both races, TCPU ranked as the leading industry division for fatalities, followed by Services. However, differences by occupation were observed between white and black workers. The greatest proportions of fatalities for white workers occurred within Transportation and Material Moving (n=4,677, 46.0%), Precision Production, Craft, and Repair (n=929, 9.1%), and Sales (n=808, 7.9%) occupations. For black workers, Transportation and Material Moving (n=708, 58.9%) also ranked the highest in number of fatalities, with Services occupations (n=120, 10.0%) and Laborers (n=98, 8.2%) ranking second and third.

Within occupations, fatality rates differed somewhat for white and black workers. Rates for Transportation and Material Moving occupations (which include truck drivers) were higher among white workers (11.30/100,000 FTEs versus 9.70/100,000 FTE). Within Sales occupations, white workers had about 1.9 times the fatality rate of black workers (0.69 versus 0.36). In two occupation groups, black workers had higher fatality rates. The rate for black workers in Farming, Forestry, and Fishing occupations was 1.3 times the rate for white workers (3.04/100,000 FTEs versus 2.31/100,000 FTEs). Black Laborers had a rate of 1.54/100,000 FTEs, compared with 1.18/100,000 FTEs among white Laborers.

2.3 NONFATAL INJURIES TO WORKERS

Data on nonfatal occupational injuries associated with highway crashes are available from SOII, a program of the BLS. SOII uses the same source and event categories as CFOI. As with CFOI data, the source of injury is the type of vehicle occupied by the injured worker. Injury estimates from SOII exclude all government workers, self-employed workers, and workers on farms with fewer than 11 employees.

In 2000, an estimated 44,863 nonfatal occupational injuries were associated with highway crashes and resulted in days away from work. The greatest numbers of nonfatal injuries by far were to workers in the Services and TCPU industry divisions (Table 10). TCPU had nearly four times the total injury rate for all industries and more than twice the injury rate of any other industry division.

In 2000, trucks and automobiles were associated with the highest frequencies and incidence rates of highway crashes in which a motorized highway vehicle was the primary injury source (Table 11). Among truck types, semi-trucks and delivery trucks were associated with the greatest

Table 10. Nonfatal injuries resulting from work-related highway crashes and requiring days away from work,* by industry division, 2000†

Industry division (SIC)	Estimated number	%	Injuries/10,000 FTEs‡
Services	14,145	31.5	5.1
TCPU	12,229	27.3	18.4
Construction	4,706	10.5	7.7
Wholesale Trade	4,520	10.1	6.7
Retail Trade	4,444	9.9	2.6
Manufacturing	2,730	6.1	1.5
Finance, Insurance, Real Estate	1,187	2.6	1.8
Agriculture, Forestry, Fishing	860	1.9	5.7
Mining	41	0.1	0.7
Total§	44,863	100.0	4.9

Source: BLS [2002] (data from the annual SOII).
*Days-away-from-work cases include those that result in days away from work with or without restricted work activity.
†Excludes self-employed workers, government workers, and agricultural establishments with fewer than 11 employees.
‡Full-time equivalent workers.
§Columns may not add to total because of rounding.

Table 11. Nonfatal injuries resulting from work-related highway crashes and requiring days away from work,* by primary source of injury, 2000†

Primary source of injury	Estimated number of injuries	Median number of days away from work	Injuries/10,000 FTEs‡
Automobile	15,325	8	1.7
Truck	14,114	18	1.5
Unspecified	6,564	18	—
Semi-truck	3,566	21	—
Delivery truck	1,948	24	—
Truck, n.e.c.§	1,124	11	—
Pickup truck	624	5	—
Dump truck	288	14	—
Van—passenger or light delivery	2,328	10	—
Bus	2,022	10	—
Motorized highway vehicle, n.e.c.	422	10	—
Motorcycle, moped	255	47	—
Motor home, recreational vehicle	81	10	—
Highway vehicle, unspecified	8,670	8	—

Source: BLS Unpublished data.
*Days-away-from-work cases include those that result in days away from work with or without restricted work activity.
†Excludes self-employed workers, government workers, and agricultural establishments with fewer than 11 employees.
‡Full-time equivalent workers.
§Not elsewhere classified.

numbers of injuries and the highest median number of days away from work. Although injuries related to motorcycles were relatively few in number, they were the most severe in terms of median number of days away from work.

Other data from SOII provide information about all occupational injuries to truck drivers. Truck drivers experienced more nonfatal occupational injuries than workers in any other occupation in 2000, accounting for 8.2% of injuries but only 2.6% of FTEs. Transportation incidents (which include highway crashes, nonhighway crashes, and pedestrian incidents) accounted for 13.5% of the estimated 136,072 injuries to truck drivers in 2000, and they were the third leading cause of injury to truck drivers after overexertion (29.6%) and contact with objects and equipment (19.4%). More than half of the overexertion injuries were associated with lifting [BLS 2002]. This fact is significant because truck drivers commonly load and unload cargo as part of their job duties.

2.4 FATAL AND NONFATAL CRASHES INVOLVING LARGE TRUCKS

FARS, a program of NHTSA, is a rich source of data on crashes involving large trucks. FARS is a national census of highway crashes in which a fatality occurred within 30 days of the crash. Data are abstracted from police crash reports, death certificates, driving records, and other sources. The National Automotive Sampling System GES, also collected by NHTSA, provides national estimates of police-reported traffic crashes occurring on public roadways and is one of the primary sources of data on nonfatal vehicle-related injuries in the general population. Another component of the National Automotive Sampling System is the Crashworthiness Data System, which collects data on approximately 5,000 passenger vehicle tow-away crashes each year. The Crashworthiness Data System does in-depth investigations using data sources such as driver interviews, crash scene inspections, vehicle inspections, and police crash reports.

FARS and CFOI classify trucks differently. FARS uses a combination of body type and weight. CFOI has fewer categories, which are based largely on the function of the truck and do not take vehicle weight into account. FARS provides data on large trucks with gross vehicle weight ratings (GVWRs)[‡] greater than 10,000 lb, whereas the closest equivalent in CFOI is the source category "semi-trucks." Although the two data systems are not directly comparable, the data collected through each are complementary. It is important to note that FARS is not restricted to work-related highway crashes, but it can be assumed that the great majority of large-truck

‡The GVWR is "the maximum rated capacity of a vehicle, including the weight of the base vehicle, all added equipment, driver and passengers, and all cargo loaded into or on the vehicle. Actual weight may be less than or greater than GVWR." [NHTSA 2001a].

crashes in which the driver is killed are work related. Responses to other FARS data elements related to commercial driver's licensure and transport of hazardous materials may also suggest that a crash occurred on the job.

2.4.1 FARS Data

In recent years, sharp increases in the number of large trucks on the road and in vehicle miles traveled by large trucks have been accompanied by an increase in the number of fatalities involving these vehicles. Between 1992 and 2000, the annual number of vehicle miles traveled increased by 34% for large trucks. FARS data show that fatalities involving large trucks increased from 4,462 in 1992 to 5,395 in 1998 (+20.9%), decreasing slightly to 5,211 in 2000 [FMCSA 2002a]. Although rates of fatal crash involvement for large trucks (number of vehicles involved per 100 million vehicle miles traveled) declined from 3.8 to 2.6 between 1988 and 1992, they have shown little improvement since that time. The fatal crash involvement rate for large trucks in 2000 was slightly higher than the rate for passenger vehicles (2.4 versus 1.9), although the rate for nonfatal injury crashes for large trucks was only one-third that of passenger vehicles (48.8 versus 142.7) [FMCSA 2002a]. Crashes involving at least one large truck accounted for 12.1% of all fatal crashes and 4.6% of nonfatal injury crashes in 2000 [FMCSA 2002a].

Occupants of large trucks accounted for 14.2% of those killed in large-truck crashes in 2000, whereas 77.9% were occupants of another motor vehicle, and the remaining 7.9% were nonoccupants such as pedestrians and pedalcyclists [FMCSA 2002a]. Of the 4,930 large trucks involved in fatal crashes in 2000, 62.4% were tractors pulling single semi-trailers, 3.0% were doubles, and 0.2% were triples [FMCSA 2002a]. It is important to note that although large trucks are defined as those with GVWR greater than 10,000 lb, the heaviest trucks were most often involved in fatal crashes. Trucks with a GVWR of more than 26,000 lb made up 87.4% of fatal large-truck crashes in 2000 [FMCSA 2002a].

Trucks with a GVWR of more than 26,000 lb made up 87.4% of fatal large-truck crashes in 2000.

Recent research has been conducted on how the actions of large-truck and passenger-vehicle drivers influence the occurrence of large-truck crashes. FARS data include "driver-related factors" that provide information about the actions of each driver involved in the crash. The presence of a driver-related factor does not imply fault but does suggest that some action taken by that driver was judged to have contributed to the crash. For the 2,714 fatal crashes in 2000 involving a passenger vehicle and a large truck with a GVWR of more than 10,000 lb, driver-related factors were recorded in 25.5% of crashes for the truck driver and in 82.2% of crashes for the passenger-vehicle driver [FMCSA 2002a]. In these multiple-vehicle events, the truck driver was most likely to have been assigned one or more driver-related factors when the truck rear-ended the passenger vehicle. The

2000 FARS data also showed that truck drivers were much more likely to be assigned a driver-related factor in fatal single-vehicle crashes (70.3%) than in fatal multiple-vehicle crashes (28.8%) [FMCSA 2002a]. Despite the fact that actions of passenger vehicle drivers are more often judged to have contributed to fatal crashes with large trucks, the same five factors are most often present for drivers of large trucks as for drivers of passenger vehicles:

- Driving too fast for conditions or in excess of the posted speed limit
- Failure to stay in the proper lane
- Running off the road
- Inattention (talking, eating, etc.)
- Failure to yield the right of way [FMCSA 2002a; NHTSA 2002b]

Two studies analyzed fatal crashes between passenger vehicles and large trucks in greater detail [Blower 1998; Stuster 1999]. The primary data source for both was Trucks Involved in Fatal Accidents (TIFA), a subset of FARS that verifies cases and collects additional data through telephone surveys. Both studies used driver-related factors collected through FARS and TIFA to assess the relative contributions of the truck driver and the passenger vehicle driver. The first study, using TIFA data from 1994 and 1995, included 5,453 fatal crashes involving two vehicles—a large truck and a passenger vehicle. In 4,551 of these crashes, only the driver of the passenger vehicle died; whereas in 90 crashes, only the truck driver died. Both the passenger vehicle driver and the truck driver died in 23 of these incidents, and neither died in the remaining 789 [Blower 1998].

The passenger vehicle driver had a driver-related factor coded in nearly 81% of the incidents, and the truck driver had a driver-related factor coded in nearly 27%. The most common scenarios fatal to the truck driver were (1) a rear-end collision in which a truck struck the passenger vehicle, (2) a passenger vehicle that turned across the truck's path, and (3) a sideswipe with both vehicles traveling in the same direction and the truck encroaching (10.6% each). The most common crash scenarios fatal to the passenger vehicle driver were (1) a head-on collision into the truck's lane (25.3%), (2) a straight path with the truck striking the passenger vehicle (16.8%), and (3) a rear-end collision with the passenger vehicle striking the truck (11.7%) [Blower 1998].

The second study [Stuster 1999] sought to identify unsafe driving acts of passenger vehicle drivers that might lead to collisions with large trucks. FARS and TIFA data were supplemented by crash reports for large-truck crashes (i.e., trucks with a GVWR greater than 10,000 lb) and interviews with collision investigation experts and truck drivers. The final product was a ranked list of unsafe driving acts based on experts' assessment of the combined danger and frequency of each act. The most critical unsafe driving acts were judged to be as follows:

- Driving inattentively (reading, talking, using the phone, fatigue)
- Merging improperly, causing the truck to maneuver or brake quickly
- Failure to stop at a stop sign or traffic signal (also stopping too early or too late)
- Failure to slow down in a construction zone
- Unsafe speed (approaching too fast from the rear or misjudging truck speed)
- Following too closely

The most common factor in truck versus passenger vehicle crashes was the passenger vehicle driver's lack of knowledge and awareness about the performance capabilities of large trucks.

The Stuster [1999] study concluded that the most common factor in truck versus passenger vehicle crashes was the passenger vehicle driver's lack of knowledge and awareness about the performance capabilities of large trucks. Specifically, drivers may be unaware of limitations in acceleration, braking, and visibility. Also, passenger vehicle drivers may not fully appreciate the extent to which the considerable size advantage of large trucks places them at risk of injury.

2.4.2 CFOI Data

CFOI showed a 64.3% increase in work-related highway deaths of semi-truck occupants from 1992 to 2000. However, the data show that the burden of work-related semi-truck crashes is shared by workers other than truck drivers. CFOI identified 4,758 worker fatalities related to semi-trucks. The majority were semi-truck occupants (3,378), followed by workers in other types of vehicles that collided with semi-trucks (1,169), and pedestrian workers struck by semi-trucks (211). Of the 3,378 semi-truck occupant fatalities, 35.6% involved noncollision events, 33.0% were collisions, and 25.4% were events involving a vehicle versus a stationary object. The truck most often struck no other object (33.0%), another semi-truck (18.1%), another vehicle (14.7%), or a guardrail or other barrier (9.9%). TCPU had the highest frequency and rate of semi-truck occupant fatalities of any industry division (n=2,509, 2.99 deaths/100,000 FTEs). Fatalities among semi-truck occupants were lowest at 9 p.m. (n=57), increasing steadily and peaking at 5 a.m. (n=172) (see Figure 4).

The 1,169 other workers killed in semi-truck incidents were most often driving or riding in automobiles (30.5%), pickup trucks (26.0%), vans (13.9%), and farm tractors (2.9%). The highest frequencies were in the Services (215) and TCPU industry divisions (177); rates were highest in

Mining (0.39) and Agriculture, Forestry, and Fishing (0.34). In contrast with fatalities of semi-truck occupants, these events occurred most frequently between 9 a.m. and 4 p.m.

2.5 DATA SUMMARY

Available data on work-related roadway crashes show an increase in the number and rate of fatalities between 1992 and 2000, despite declines in work-related fatalities as a whole. According to CFOI data, collisions between vehicles made up nearly half the fatal events, followed by noncollision events and collisions in which the worker's vehicle left the highway and struck a stationary object on the roadside. Workers who were occupants of trucks accounted for nearly 58% of all fatalities; nearly half of these were semi-truck occupants. However, crashes involving semi-trucks affect workers in vehicles that collide with semi-trucks as well as pedestrian workers.

CFOI data also reveal that workers employed in the TCPU industry division (which includes commercial trucking) were at highest risk of fatality. Those employed in Transportation and Material Moving occupations (truck drivers in particular) had far higher fatality rates than workers in any other occupation group. Fatality risk varied across age groups: workers aged 65 or older had more than three times the fatality risk of workers of all ages; and workers younger than age 20 (who might be expected to have less exposure to vehicles in the workplace) had fatality rates similar to those for workers of all ages.

Data from DOT sources provide additional information about crashes involving large trucks with a GVWR of more than 10,000 lb. The number of fatal crashes involving large trucks decreased slightly in 2000 following a 21% increase between 1992 and 1998. Large-truck crashes involving fatalities are much more often fatal to occupants of vehicles other than the truck. Studies suggest that factors such as driving too fast for conditions, failure to keep in the proper lane, and inattention are commonly present in fatal crashes involving large trucks and that these factors are more often noted for the drivers of vehicles other than the truck.

These results provide valuable information, identifying groups of workers at highest risk and general circumstances under which crashes occur. The following reviews of safety regulations and the scientific literature complement the data analysis, providing insight into how the problem of work-related crashes is being addressed through regulatory measures and through research to increase understanding of risk factors and identify promising prevention strategies.

3 FEDERAL REGULATIONS AND STANDARDS ADDRESSING OCCUPATIONAL ROADWAY SAFETY

Two Federal agencies in DOT—FMCSA and NHTSA—hold primary responsibility for developing and enforcing safety standards related to vehicle design and operation. Motor carrier safety is the responsibility of the FMCSA, established by the Motor Carrier Safety Improvement Act of 1999 as a new operating administration within DOT, effective January 1, 2000. FMCSA regulations cover commercial motor carriers, including long-haul trucking. NHTSA regulations set forth minimum design and safety performance requirements to which all vehicle manufacturers must conform. Three other agencies play roles in protecting workers who operate motor vehicles on the job. First, the National Transportation Safety Board, though not a regulatory agency, investigates selected roadway crashes and develops safety recommendations directed at Federal and State agencies and other groups. Second, the DOL's Employment Standards Administration, Wage and Hour Division, enforces child labor provisions of the Fair Labor Standards Act (FLSA) that define conditions under which workers aged 17 and under may operate a motor vehicle. Finally, the Occupational Safety and Health Administration (OSHA), also part of DOL, has regulations covering certain industries that address vehicle and equipment operation, primarily operation of machinery and equipment off the highway.

3.1 FEDERAL MOTOR CARRIER SAFETY REGULATIONS

Federal Motor Carrier Safety Regulations, found in 49 CFR* 301 through 399, cover businesses that operate commercial motor vehicles† (CMVs) in interstate commerce.‡ Motor carriers§ engaged in intrastate commerce only are not directly subject to these regulations. However, intrastate motor carriers are subject to State regulations, which must be identical to or compatible with the Federal regulations in order for States to receive motor carrier safety grants from FMCSA. States have the option of exempting CMVs with a GVWR under 26,001 lb.

The portions of the Federal Motor Carrier Safety Regulations summarized in this section were chosen for their direct relevance to occupational safety and represent only a small portion of the regulations found in 49 CFR.

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*Code of Federal Regulations. See CFR in references.

†Commercial motor vehicle is any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle

(1) has a GVWR or gross combination weight rating, or gross vehicle weight or gross combination weight of 4,537 kg (10,001 lb) or more, or
(2) is designed or used to transport more than 8 passengers (including the driver) for compensation, or
(3) is designed or used to transport more than 15 passengers (including the driver) and is not used to transport passengers for compensation, or
(4) is used in transporting material found by the Secretary of Transportation to be hazardous under 49 U.S.C. 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C [49 CFR 390.5].

‡Interstate commerce is trade, traffic, or transportation in the United States

(1) between a place in a State and a place outside of such State (including a place outside of the United States),
(2) between two places in a State through another State or a place outside of the United States, or
(3) between two places in a State as part of trade, traffic, or transportation originating or terminating outside the State or the United States [49 CFR 390.5].

§Motor carrier is a for hire motor carrier or a private motor carrier. The term includes a motor carrier's agents, officers, and representatives as well as employees responsible for hiring, supervising, training, assigning, or dispatching of drivers and employees concerned with the installation, inspection, and maintenance of motor vehicle equipment and/or accessories [49 CFR 390.5].

3.1.1 Commercial Driver's License Standards, Requirements, and Penalties [49 CFR 383]

Drivers must obtain a commercial driver's license if they are engaged in intrastate, interstate, or foreign commerce and if they operate a vehicle that meets the definition of a CMV.

The commercial driver's license program originated with the commercial Motor Vehicle Safety Act of 1986. The goal of the Act is to improve highway safety by ensuring that drivers of large trucks and buses are qualified to operate these vehicles and to disqualify and remove unqualified and unsafe drivers. Drivers must obtain a commercial driver's license if they are engaged in intrastate, interstate, or foreign commerce and if they operate a vehicle that meets the definition of a CMV. The minimum age at which a driver may obtain a commercial driver's license is 21. The licenses are issued for the following classes of vehicles:

- Class A—Any combination of vehicles with a gross combination weight rating of 26,001 lb or more, provided the GVWR of the vehicle(s) being towed is more than 10,000 lb
- Class B—Any single vehicle with a GVWR of 26,001 lb or more, or any such vehicle towing a vehicle with a GVWR of no more than 10,000 lb
- Class C—Any single vehicle or combination of vehicles that does not meet the definition of Class A or B but is either designed to transport 16 or more passengers (including the driver) or is placarded for hazardous materials.

Key Provisions of 49 CFR 383

- Commercial vehicle drivers may have only one driver's license [49 CFR 383.21].
- A driver must notify the employer within 30 days of a conviction for any traffic violation other than a parking violation. In the event of license suspension, revocation, or any other disqualification from driving, the driver must notify the employer the next business day [49 CFR 383.31, 49 CFR 383.33].
- If a commercial driver's license holder is convicted of any of the following major offenses, he or she will be disqualified from driving a CMV for a period of 1 year to life: leaving the scene of an accident; committing a felony using a CMV; driving a CMV under the influence of a controlled substance or with a blood alcohol concentration of 0.04% or higher; refusing to take an alcohol test; driving a CMV under a revoked, suspended, or canceled commercial driver's license, or while disqualified; or causing a fatality through negligent operation of a CMV [49 CFR 383.51, as amended in 67 Fed. Reg.* 49742 (2002)]. Serious traffic violations, violations of out-of-service orders, and railroad-highway grade crossing offenses result in disqualification for periods of 60 days to 1 year [49 CFR 383.51, as amended in 67 Fed. Reg. 49742 (2002)].

**Federal Register*. See Fed. Reg. in references.

- A commercial driver's license holder will be disqualified from driving a CMV if convicted of any of the major or serious offenses cited above, regardless of whether the offense was committed while driving a CMV [49 CFR 383.51, as amended in 67 Fed. Reg. 49742 (2002)].
- The Assistant Administrator of the FMCSA (or designee) is required to make an emergency disqualification of any driver whose driving constitutes an "imminent hazard" [49 CFR 383.5, 49 CFR 383.52 (amended in 2002); 67 Fed. Reg. 49742 (2002)].
- An employer may not knowingly permit a driver to operate a CMV if the driver's license has been suspended or revoked; if the driver has more than one CMV driver's license; if the company, driver, or vehicle is under an out-of-service order; or if the driver violates any regulation governing railroad-highway grade crossings [49 CFR 383.37].
- Applicants for commercial driver's licenses must provide the names of all States where they have been licensed to drive any type of motor vehicle during the previous 10 years [49 CFR 383.71 (amended in 2002); 67 Fed. Reg. 49742 (2002)], and the State where the application is made must request and review the applicant's complete driving record from all these States before issuing a commercial driver's license [49 CFR 384.206, as amended in 67 Fed. Reg. 49742 (2002)].
- Drivers must pass a general knowledge test. Required knowledge areas include proper use of vehicle control systems and safety features, backing rules and procedures, visual search methods, speed management, night driving, hazard perception, the relationship of cargo to vehicle control, vehicle inspection procedures, vehicle maneuvering in emergency situations, hazardous materials transport, and air brake systems. Drivers who will operate combination vehicles such as tractor-trailers must also understand coupling and uncoupling procedures and vehicle inspection procedures for combination vehicles [49 CFR 383.111].
- Drivers must also demonstrate driving skills for each vehicle group they intend to operate. Skill areas to be tested include basic vehicle control (starting, stopping, or moving forward and in reverse), safe driving skills (lane changes, turns, signaling, speed control, visual search, and following distance), and air brake inspection and operation skills. Testing must be performed on the road [49 CFR 383.113].

3.1.2 Qualifications of Drivers [49 CFR 391]

This section describes the process by which drivers must demonstrate that they are physically qualified to operate a CMV. The process also requires an annual inquiry and review of each driver's safety record.

Key Provisions of 49 CFR 391

- A prospective CMV driver must possess a currently valid commercial driver's license issued by only one State or jurisdiction [49 CFR 391.11].
- An individual is not permitted to drive a CMV unless he/she has first demonstrated the ability to conduct a pre-trip inspection (as specified in 49 CFR 392.7), place the vehicle in operation, operate controls and emergency equipment, operate the vehicle in traffic (including passing other vehicles, turning, braking, slowing down), back and park the vehicle, and coupling and uncoupling combination units if the driver intends to operate combination vehicles [49 CFR 391.31].
- Persons with certain physical, functional, or mental disorders that may interfere with ability to safely operate and control a CMV are not permitted to drive a CMV. Disqualifying medical conditions include clinically diagnosed insulin-treated diabetes, heart disease, high blood pressure, epilepsy, respiratory dysfunction, alcoholism or drug dependency, and psychiatric disorders [49 CFR 391.41].
- Persons with any impairment of extremities that might interfere with normal tasks associated with vehicle operation are not permitted to drive a CMV [49 CFR 391.41].
- CMV drivers must have distance vision of at least 20/40 in each eye (with or without corrective lenses), horizontal field of vision of at least 70º in both eyes, and the ability to distinguish the colors of red, green, and amber on traffic signals [49 CFR 391.41].
- CMV drivers must be able to hear a forced, whispered voice at a distance of 5 feet (with or without a hearing aid). Hearing may also be tested using an audiometric device. In this case, the hearing loss in the better ear cannot be more than 40 decibels at 500, 1,000, and 2,000 Hz (with or without a hearing aid) [49 CFR 391.41].

Motor carrier employers must make an annual inquiry into the driving record of each driver employed.

- Motor carrier employers must make an annual inquiry into the driving record of each driver employed. The inquiry, covering at least the preceding 12 months, must be made to the appropriate agency of every State in which the driver held a commercial driver's license or permit during the time period [49 CFR 391.25].

The regulations include a standard form for reporting of medical exam results, and detailed instructions for the health care professional performing a medical exam for a prospective driver [49 CFR 391.43]. ■

Future Plans

In July 2001, the FMCSA stated its intent to issue exemptions that would allow qualifying drivers with insulin-treated diabetes to operate CMVs in interstate commerce. The proposed exemptions were supported by recent studies showing that drivers with this condition have crash rates similar to or lower than comparison groups or the national rate. Drivers applying for the exemption would have to document no recent history of hypoglycemic reactions, seizures, or other disqualifying medical conditions. Drivers with recent at-fault accidents, convictions for serious traffic offenses, or license suspensions or revocations would be ineligible for the exemption. The FMCSA proposal calls for a strict glucose management protocol and periodic re-evaluations by medical specialists [66 Fed. Reg. 39548 (2001)].

3.1.3 Driving of Commercial Motor Vehicles [49 CFR 392]

This section contains the rules for the safe operation of motor vehicles; it delineates the responsibilities of the driver and the responsibilities of the motor carrier.

Key Provisions of 49 CFR 392

- Drivers are not permitted to operate a CMV if ability or alertness is impaired by fatigue or illness or for any other reason, nor may motor carriers require or permit a driver to operate a CMV under any of these circumstances [49 CFR 392.3].
- Drivers are not permitted to operate a CMV while under the influence of a controlled substance (except for prescription drugs that will not affect safe operation), nor may motor carriers require or permit a driver to operate a CMV in violation of any of these provisions [49 CFR 392.4]. (Procedures for drug and alcohol testing in transportation workplaces are addressed in 49 CFR 40 and 382.)
- Drivers may not use alcohol or be under the influence of alcohol within 4 hours of going on duty or operating or having physical control of a CMV. In addition, a driver may not use or be in possession of alcoholic beverages while working. Any driver violating these regulations is immediately placed out of service (prohibited from driving) for 24 hours [49 CFR 392.5].
- Motor carriers must not schedule work such that a vehicle would have to be operated above the speed limit to travel between points within a certain time period [49 CFR 392.6].

- Drivers must conduct a pre-trip inspection to ensure that vehicle parts such as horn, windshield wipers, mirrors, coupling devices, lights, and brakes are in good working order [49 CFR 392.7].
- Drivers must ensure that cargo is properly distributed and secured as specified in 49 CFR 393.100 and 49 CFR 393.106; they must also ensure that cargo does not interfere with the driver's view, movement of arms and legs, access to controls, and ability to exit from the vehicle. Drivers must also re-examine the cargo and load-securing devices periodically throughout the trip [49 CFR 392.9].
- The driver of any CMV that has a seat belt assembly installed at the driver's seat must be restrained within the seat belt assembly before operating the vehicle [49 CFR 392.16].

3.1.4 Parts and Accessories Necessary for Safe Operation [49 CFR 393]

This section contains exhaustive specifications for CMV parts and accessories, including requirements for protections against shifting and falling cargo [49 CFR 393.100, 49 CFR 393.104, 49 CFR 393.106].

Recent Changes to 49 CFR 393

- Trucks and buses manufactured after March 1, 1999, must be equipped with an antilock brake system and a malfunction indicator system for the antilock brake system that meet requirements of the NHTSA Federal Motor Vehicle Safety Standards [49 CFR 393.55].
- Trailers and semi-trailers with a GVWR of 10,000 lb or more manufactured on or after January 26, 1998, must be equipped with a rear impact guard that meets the NHTSA standards [49 CFR 393.86].
- Trailers and semi-trailers manufactured before December 1, 1993, must be retrofitted with retroreflective sheeting or reflex reflectors [66 Fed. Reg. 30335 (2001)]. The regulations specify the size, color, placement, and number of sheeting strips or reflectors [49 CFR 393.13]. A NHTSA standard (49 CFR 571, Standard No. 108) already requires these on trailers or semi-trailers manufactured on or after December 1, 1993.

3.1.5 Hours of Service of Drivers [49 CFR 395]

This group of regulations specifies maximum hours of driving time and duty time for CMV drivers. The motor carrier and the driver are each responsible for following these regulations. Certain motor carriers and drivers are subject to different hours-of-service regulations. These include agricultural operations, oilfield operations, utility service vehicles, and drivers in Alaska and Hawaii. State laws that are more protective of groups exempted from hours-of-service regulations supersede Federal laws.

Revisions to 49 CFR 395, effective January 4, 2004, have separate hours-of-service provisions for property-carrying CMV drivers and passenger-carrying CMV drivers [68 Fed. Reg. 22456 (2003)]. Although the revision allows property-carrying CMV drivers to drive 1 hour more than passenger-carrying CMV drivers, the property-carrying drivers are also permitted 1 hour less of total time on duty. Elements in the proposed rule that would have required two consecutive periods of night rest for all drivers and electronic on-board recorders for long-haul and regional drivers [65 Fed. Reg. 25540 (2000)] were not part of the final rule.

Key Provisions of 49 CFR 395

For drivers of property-carrying CMVs:

- Effective January 4, 2004, drivers may not drive
  —for more than 11 hours after 10 consecutive hours off duty, or
  —for any period of time after having been on duty 14 hours following 10 consecutive hours off duty.

Here, *on duty* means all time the driver is required to work or be ready to work. This includes time spent driving, loading, unloading, inspecting, repairing, or waiting to be dispatched [49 CFR 395.2].

For drivers of passenger-carrying CMVs:

- Drivers may not drive
  —for more than 10 hours after 8 consecutive hours off duty, or
  —for any period of time after having been on duty 15 hours following 8 consecutive hours off duty.

For all CMV drivers:

- Drivers may not after having been on duty 60 hours in 7 consecutive days (if the motor carrier does not operate 7 days a week), or after having been on duty 70 hours in 8 consecutive days (if the motor carrier operates 7 days a week) [49 CFR 395.3].
- If drivers use a sleeper berth, they may divide the required off-duty hours (8 hours for passenger-carrying drivers and 10 hours for property-carrying drivers) into two periods, neither of which may be less than 2 hours long.
- Drivers must maintain a record of duty status for each 24-hour period [49 CFR 395.8].
- Drivers are declared out of service if they are in violation of the hours-of-service regulations, or if they have not maintained a current record of duty status. After being declared out of service, they may not operate a CMV again until they have gone off duty for the prescribed number of hours (8 hours for passenger-carrying drivers and 10 hours for property-carrying drivers) [49 CFR 395.13].

3.1.6 Inspection, Repair, and Maintenance [49 CFR 396]

This section describes driver and motor carrier responsibilities for vehicle inspection, repair, and maintenance. Appendix G to Part 396 lists minimum standards for the required periodic inspection of CMVs.

Key Provisions of 49 CFR 396

- Motor carriers must systematically inspect, repair, and maintain all motor vehicles under their control [49 CFR 396.3]. Operation of a motor vehicle in a condition that is likely to cause an accident is not permitted [49 CFR 396.7].
- Motor carriers must require all drivers to prepare a written report at the end of each day's work on every vehicle operated that day. At a minimum, the report must cover brakes, steering, lights, reflectors, tires, horns, windshield wipers, rear vision mirrors, coupling devices, wheels and rims, and emergency equipment [49 CFR 396.11].
- If the driver's written report identifies any defect or deficiency that may affect safe operation, the motor carrier must repair these defects before the vehicle may again be operated [49 CFR 396.11].
- A CMV may be used only if each component identified in Appendix G has passed inspection at least once during the previous 12 months. Documentation of the inspection must be kept on the vehicle [49 CFR 396.17].

3.2 NHTSA VEHICLE SAFETY STANDARDS

The NHTSA Federal Motor Vehicle Safety Standards [49 CFR 571] apply to all motor vehicles built for sale or use in the United States.

The NHTSA Federal Motor Vehicle Safety Standards [49 CFR 571] apply to all motor vehicles built for sale or use in the United States. Vehicles manufactured overseas for the U.S. market are also covered by these regulations, whereas those built in the United States for export are not. FMCSA regulations that set performance standards for CMVs reference the Federal Motor Vehicle Safety Standards. Because these standards apply to all passenger vehicles built for sale or use in the United States, they are also relevant to fleet vehicles purchased for employee use and to personal vehicles driven for work.

The Federal Motor Vehicle Safety Standards cover both the crash avoidance and crashworthiness aspects of vehicle design. Crash avoidance standards include specifications for controls and displays, brake systems, headlights and reflective devices, tire selection, and mirrors. In some areas such as tire selection, separate standards exist for passenger vehicles and other motor vehicles. Specific to trucks, buses, and trailers is a standard addressing performance, equipment, and testing requirements for air-brake systems [49 CFR 571, Standard No. 121]. This standard became effective in 1975, but its requirements for stopping distances were removed in 1978 as a result of a court decision. These requirements were reinstated in 1997, and the standard was modified to require the addition of antilock brakes to air-brake systems [49 CFR 571, Standard No. 121; Krall 2002]. Requirements for antilock brakes and maximum stopping distances have also been extended to all multipurpose passenger vehicles, trucks, and buses equipped with hydraulic or electric braking systems and having a GVWR greater than 10,000 lb [49 CFR 571, Standard No. 105].

Crashworthiness standards address aspects of occupant protection such as protection from impact from the steering control system, air bags, child restraint systems, windshield mounting, side impact protection, and roof crush resistance. Standard No. 208 contains requirements for lap or lap-and-shoulder-belt assemblies in passenger vehicles, buses (driver's seat only), and trucks [49 CFR 571, Standard No. 208]. Although Standard No. 208 still requires only lap belts in trucks with a GVWR of 10,000 lb or more, U.S. manufacturers have voluntarily installed shoulder-belt restraint systems in these vehicles since the late 1980s [Krall 2002]. Also of relevance to CMVs are crashworthiness standards that address emergency exits and window releases in buses, rear impact protection, and rear impact guards [49 CFR 571, Standard Nos. 217, 223, and 224]. Rear impact guards, required for installation on trailers and semi-trailers with a GVWR of 10,000 lb or more, are designed to reduce deaths and injuries that occur when lighter vehicles strike the rear of a trailer or semi-trailer.

3.3 NATIONAL TRANSPORTATION SAFETY BOARD

The National Transportation Safety Board is an independent agency that investigates major incidents related to all modes of transportation, conducts special studies on topics such as highway work zone safety and operator fatigue, and directs safety recommendations to Federal and State agencies, manufacturers, trade associations, private industry, labor, and others [Baxter 1995; Sweedler 1995]. The National Transportation Safety Board uses a multidisciplinary approach to crash investigation that (when appropriate) draws on specialized technical experts from outside the agency to assist the Board's investigative staff. The investigative process usually spans several months and includes public hearings, a public board meeting, and issuance of incident-specific safety recommendations in addition to a written investigative report.

Because the volume of roadway crashes precludes investigation of all incidents, the National Transportation Safety Board investigates a small proportion of roadway crashes selected in cooperation with States. However, results of these investigations often suggest a need for broader study of particular safety issues and lead to creation of public forums for discussion. A recent example involving commercial vehicles was a public hearing on truck and bus safety in April 1999, which was prompted by an Illinois collision between an Amtrak train and a semi-trailer at a grade crossing and by a New Jersey motorcoach crash [NTSB 2000].

The National Transportation Safety Board monitors actions taken in response to each recommendation, advising the public and Congress if no reply has been received from the entity to which the recommendation was addressed. An example of this type of activity is the long-term monitoring of efforts by DOT over the past decade to address operator fatigue in all modes of transportation [NTSB 2000]. The Board has also created the "Most Wanted" List of Transportation Safety Improvements to advise the public of the need for critical safety improvements. Several current "Most Wanted" recommendations relate to occupational motor vehicle safety. They include a recommendation to the FMCSA to establish scientifically based regulations for CMV drivers that set limits on hours of service and establish predictable schedules for work and rest. Another group of recommendations addresses motorcoach safety issues such as the development of NHTSA performance standards for motorcoach occupant protection systems and a proposed NHTSA requirement that newly manufactured motorcoaches and school buses be equipped with on-board devices to record vehicle performance and event or crash data [NTSB 2002].

3.4 FAIR LABOR STANDARDS ACT (FLSA)

3.4.1 Child Labor

The FLSA regulates employment of persons aged 17 and younger by firms engaged in interstate commerce with annual gross revenues of at least $500,000. The basic minimum age for employment is 14 years in agricultural occupations and 16 years in nonagricultural occupations, though youths aged 14 and 15 may perform a limited number of activities in nonagricultural occupations. The FLSA also identifies 17 nonagricultural occupations declared by the Secretary of Labor to be particularly hazardous for 16- and 17-year-olds. Hazardous Order No. 2 addresses the occupations of motor vehicle driver and outside helper. On October 31, 1998, Congress passed the Teen Drive for Employment Act (Public Law 105–334), which modified the FLSA and Hazardous Order No. 2 to prohibit all on-the-job driving by 16-year-olds.

Key Provisions of the FLSA

- Under the Teen Drive for Employment Act, no person under age 17 may drive on public roadways as part of his or her job if that employment is subject to the FLSA.
- Workers aged 17 may drive only if the following conditions are met:

  —The driving must be limited to daylight hours.

  —The youth must have a State driver's license valid for the type of driving to be performed.

  —The youth must have completed a State-approved driver education course and must have a record of no moving violations at the time of hire.

  —The vehicle to be driven must be equipped with a seat belt for the driver and any passengers, and the employer must instruct the youth that the seat belt is to be worn while driving the vehicle.

  —The vehicle to be driven does not exceed a gross vehicle weight of 6,000 lb.
- Workers aged 17 may not perform the following driving tasks:

  —Towing vehicles

  —Route deliveries, route sales, or urgent, time-sensitive deliveries

  —Transportation for hire of property, goods, or passengers

  —Transporting more than three passengers (including other workers)

  —Driving beyond a 30-mile radius of the youth's place of employment

  —Making more than two trips away from the primary place of employment in a single day to deliver goods to a customer or to transport passengers other than workers
- The Teen Drive for Employment Act clarified the original Hazardous Order No. 2 (which allowed "incidental and occasional driving") by stipulating that a youth aged 17 may drive for no more than one-third of the work time during any workday and no more than 20% of any workweek. ■

A youth aged 17 may drive for no more than one-third of the work time during any workday.

3.4.2 Motor Carrier Exemption

Workers who fall under the jurisdiction of the Federal Motor Carrier Safety Regulations are exempt from the overtime provisions of Section 7 of the FLSA, which guarantees compensation at 1½ times the regular rate for work beyond a 40-hour workweek. This exemption applies to motor carrier employees whose duties affect the safety of the operation of motor vehicles that transport passengers or property on public highways (e.g., drivers, driver's helpers, loaders, and mechanics) [DOL 2002].

3.5 OSHA REGULATIONS

OSHA regulations for certain industries specify that seat belts must be installed on most specialized vehicles and equipment. However, these regulations are limited to equipment designed for operation at off-highway work sites. They apply to industries such as logging [29 CFR 1910.266] and construction [29 CFR 1926.601 and 29 CFR 1926.602].

4 SPECIAL TOPICS

4.1 DRIVER FATIGUE

4.1.1 Scope of the Problem

Driver fatigue has been identified as a leading contributor to roadway crashes among workers as well as the general population. Fatigue affects driving performance by impairing information processing, attention, and reaction times; it may also cause a driver to fall asleep. Time of day, duration of wakefulness, inadequate sleep, sleep disorders, and prolonged work hours have all been identified as major causes of fatigue [Akerstedt 2000].

Estimated proportions of fatal crashes attributable to driver fatigue vary substantially and may be higher among CMVs than in the general population. Driver drowsiness or fatigue was implicated in 1,773 fatal crashes (3.1%) in the United States in 2000 [NHTSA 2001a]. However, fatigue was noted for 7.4% of drivers of large trucks involved in fatal, single-vehicle crashes [FMCSA 2002a]. Fatigue was implicated in only 1.0% of large-truck drivers involved in fatal, multiple-vehicle crashes.

Estimated proportions of fatal crashes attributable to driver fatigue vary substantially.

The Federal Highway Administration reported that driver fatigue contributes to an estimated 15% to 33% of crashes that were fatal only to occupants of large trucks. They note in contrast that only 1% to 2% of large-truck crashes fatal to pedestrians or occupants of other vehicles are judged to be fatigue-related [GAO 1999]. More recently, the FMCSA estimated that fatigue is involved in 15% of all fatal large-truck-related crashes. The agency estimated that fatigue is directly involved in 4.5% of these crashes, and that the mental lapses and inattention associated with fatigue contribute an additional 10.5%. Fatigue-related fatal crashes involving CMVs are most common in long-haul trucking, which accounts for 480 (63.6%) of the estimated 755 such events that occur annually [65 Fed. Reg. 25540 (2000)].

4.1.2 Factors Affecting the Estimated Role of Driver Fatigue

Several factors contribute to the wide range of estimates on the proportion of crashes attributable to fatigue:

- A lack of agreement about the definition of fatigue

- The subjectivity involved in making a determination about fatigue at the scene of a crash
- A frequent lack of witnesses or physical evidence at the crash scene (these fatigue-related crashes are disproportionately single-vehicle incidents)

Investigators may presumptively attribute a crash to fatigue based on the time of the incident, the driver's work and sleep schedules over the previous few days, and evidence at the crash scene that the driver did not attempt to avoid the crash.

4.1.3 Research on Driver Fatigue

In general, crash risk has been shown to increase with hours of driving.

Most of the research on driver fatigue among those who drive on the job has focused on the motor carrier industry [Braver et al. 1992; Feyer et al. 1997; Hertz 1988; Jones and Stein 1987; Kaneko and Jovanis 1992; Lin et al. 1993, 1994; McCartt et al. 2000; NTSB 1995, 1999; Williamson et al. 1996; Wylie et al. 1996]. Numerous studies have addressed the associations of time of day and hours of driving with crash risk for large trucks, drawing varying conclusions about the relative contributions of each. In general, crash risk has been shown to increase with hours of driving [Jones and Stein 1987; Kaneko and Jovanis 1992; Lin et al. 1993, 1994]. Other research has demonstrated that truck drivers as a group do not necessarily obtain adequate rest under the current hours-of-service regulations [Brown 1994; McCartt et al. 2000; Wylie et al. 1996]. A number of studies have concluded that night driving is associated with increased crash risk—particularly for single-vehicle crashes, which are likely to be fatigue-related [Blower and Campbell 1998; Campbell 2002; Hamelin 1987; Hertz 1988; Kaneko and Jovanis 1992; Lin et al. 1993]. In addition, factors such as regularity of schedule, night rest, and taking rest breaks have all been cited as being associated with reduced crash risk [Hamelin 1987; Kaneko and Jovanis 1992; Lin et al. 1993, 1994].

Two related studies of the trucking industry concluded that number of hours driven had the strongest direct effect on crash risk. Crash likelihood increased steadily after 4 hours of driving, with risks in the 9th and 10th hours that were 80% and 130% higher, respectively, than those for the first 4 hours [Lin et al. 1993, 1994]. The finding that crash risk decreased in the 6th and 7th hours among drivers who had taken a rest break between hours 2 and 6 confirms the importance of breaks in reducing crash risk [Lin et al. 1994]. A case-control study of large trucks matched by roadway, time of day, and day of week found that drivers who were on the road for more than 8 hours had 1.8 times the crash risk of those who had driven 2 hours or fewer [Jones and Stein 1987]. Another study that compared drivers by weekly driving pattern and crash involvement reported significant increases in crash risk after 4 hours of driving, with the sharpest increase after

9 hours [Kaneko and Jovanis 1992]. An analysis of TIFA data for 1981–1996 reported nearly identical results [Campbell 2002]. Work practices such as driving for more than 10 consecutive hours, taking fewer than 8 hours off duty, and driving greater numbers of hours over a 7-day period were highly predictive of falling asleep at the wheel in a group of 593 long-distance truck drivers [McCartt et al. 2000].

Night driving coupled with fatigue has also been associated with increased crash risk, higher proportions of injury-producing crashes, and greater likelihood of fatality in a crash. Between 1992 and 2000, work-related fatalities among semi-truck occupants were lowest at 9 p.m. (n=57), increasing steadily and peaking at 5 a.m. (n=172) (see Figure 4). In an analysis of TIFA data for 1981–1996 [Campbell 2002], the distribution of the risk of fatigue involvement, given a fatal large-truck crash, mirrors the pattern of early-morning fatalities in the CFOI data displayed in Figure 4. Another study reported that driving between 8 p.m. and 7 a.m. was associated with 1.9 times the crash risk during daytime hours. Driving 11 hours or more increased the relative risk associated with night driving to 2.4 [Hamelin 1987]. In two other studies, most of the driving patterns identified as posing the highest crash risk involved substantial periods of driving between midnight and 10 a.m. [Kaneko and Jovanis 1992; Lin et al. 1993]. In other research, all but one of the four 2-hour periods associated with the highest crash risk (independent of other variables) were during evening or early morning hours [Lin et al. 1994]. Lowest risk was associated with frequent driving between 6 a.m. and 2 p.m. and following a regular driving schedule. This group of low-risk drivers also tended to have off-duty time between 6 p.m. and 4 a.m., which increased the opportunity to obtain nighttime rest.

Night driving coupled with fatigue has also been associated with increased crash risk.

Other research provides further evidence of a link between night driving and the risk of large-truck crashes, reporting that long-haul trucks had more than twice the risk of crashes for the hours between 9 p.m. and 6 a.m. compared with daytime hours [Blower and Campbell 1998]. The hours between midnight and 6 a.m. were associated with the highest rate of injuries per 1,000 crashes (435 versus 320 for other hours of the day). Injuries during these hours were also more severe, with nearly twice as many fatalities per 1,000 injuries. Citing FARS data from 1993–1995, the authors noted an excess of single-vehicle crashes among long-haul truck crashes between midnight and 6 a.m. (21% at night versus 15% at other times of the day). For single-vehicle crashes involving long-haul trucks, fatigue was cited as a FARS driver-related factor for the truck driver in 19% to 21% of the crashes occurring between midnight and 6 a.m.—compared with fewer than 10% of the crashes that occurred throughout the day. This study estimated that 531 excess deaths occur per year among truck drivers and other road users as a result of night trucking operations.

Campbell [2002] used TIFA data to examine fatal fatigue-related crashes by (1) type of motor carrier employer (for-hire carriers whose primary business is transporting goods belonging to someone else versus private carriers who operate trucks to move their own goods), (2) type of truck (single-unit "straight" trucks versus semi-trucks), and (3) the length of trip one way (local versus 50 to 200 miles versus more than 200 miles). The highest relative risks of a fatal fatigue-related crash per vehicle mile traveled were found among drivers of straight trucks employed by for-hire carriers (3.41) and by private carriers (2.47). However, the number of fatal fatigue-related crashes in this population was quite small. More than half of fatal large-truck crashes in which fatigue was implicated involved for-hire semi-trucks on one-way trips of more than 200 miles. Compared with all other large-truck crashes, this group of semi-trucks had 1.9 times the risk of fatigue involvement per vehicle mile traveled. For all lengths of trips, drivers employed by for-hire carriers had a substantially higher risk of a fatigue-related fatal crash than did drivers employed by private carriers.

Insufficient sleep during off-duty time before and during a trip as well as chronic, accumulated fatigue are recognized crash risk factors that fall outside the scope of hours-of-service regulations in the United States and other nations [Brown 1994; Feyer et al. 1997; Hartley 1997; NTSB 1995]. A field study that evaluated four different driving schedules found that drivers got inadequate rest regardless of schedule, averaging 3.8 to 5.4 hours of sleep daily. Cumulative fatigue (as indicated by decreased scores on a test of vigilance) was observed during the last days of a trip, and driver self-assessment suggested higher fatigue levels after multiple trips [Wylie et al. 1996]. In another field study, fatigue increased markedly for all three driving regimens tested over the course of a 900-kilometer trip. Pre-trip sleep for the average driver in this Australian study was only slightly more than 6 hours [Williamson et al. 1996].

4.1.4 Regulations Addressing Driver Fatigue

The U.S. regulations addressing driver fatigue and driving time have changed twice since their establishment in 1937.

The U.S. regulations addressing driver fatigue and driving time have changed twice since their establishment in 1937 (see Section 3.1.5 for a more detailed discussion of existing and revised regulations). A rule change in 1962 reduced the mandatory off-duty period from 9 to 8 hours and required on-duty periods to be separated by 8 hours off duty. In addition, the 1962 rule change retained a limit of 10 hours of driving during a duty period, but it dropped a provision that the driving occur over a 24-hour period. Revisions to the hours-of-service regulations in 2003 increased the permissible hours of driving for property-carrying CMV drivers from 10 hours to 11 hours, but they decreased the maximum on-duty hours from 15 to 14 [68 Fed. Reg. 22456 (2003)]. These revisions take effect on January 4, 2004.

Under U.S. regulations applicable to property-carrying CMV drivers through 2003, two extreme work patterns are possible, each with characteristics that may contribute to driver fatigue. One pattern compresses the workday into an 18-hour drive-rest cycle of 10 hours of driving and 8 hours off duty. This pattern disrupts the normal 24-hour sleep-wake cycle. Alternatively, a driver may legally drive for 10 hours and spend an additional 5 hours on duty within a single shift, a practice that exceeds the usual maximum work shift in most other industries. In fact, only 10% of all U.S. workers worked more than a 12-hour shift during 1997 [NIOSH 2000].

The revised regulations make it possible for property-carrying CMV drivers to approximate a 24-hour work-rest cycle if they work the maximum number of duty hours (14 hours on duty and 10 hours off duty). However, the new regulations still allow a compressed drive-rest cycle of 21 hours (11 hours driving and 10 hours off duty) that disrupts the normal 24-hour sleep-wake cycle. The safety consequences of increasing maximum driving time to 11 hours remain to be seen, as research generally shows that crash risk increases with hours of driving.

The safety consequences of increasing maximum driving time to 11 hours remain to be seen.

Unlike U.S. regulations, European Union regulations require breaks within a driving trip. They allow a maximum of 9 hours of driving daily (up to 10 hours twice during a week), with a mandatory 45-minute break after 4½ hours of driving. A minimum of 11 consecutive hours off duty is required daily; this number may be reduced to 9 hours three times per week [European Economic Community 1985]. In addition, European Union regulations require that drivers be compensated for compulsory rest time, and drivers must rest 45 consecutive hours for every 6 days worked [FHWA 2000]. Although European regulations permit fewer hours of driving per day and require mandatory breaks, shortcomings have been noted: European regulations do not address the issue of adequate sleep before a trip, and they do not consider the time of day that driving may begin and end [Brown 1994].

A recent European Union directive addresses the ancillary duties that may not be accounted for when calculating hours of service for truck drivers. This directive offers a broad definition of "working time" that encompasses driving, loading and unloading, vehicle cleaning, maintenance, and waiting time. Under this directive, average weekly working time for drivers may not exceed 48 hours per week over a 4-month period, and drivers may not work more than 6 consecutive hours without a break (using the above definition of "working time") [European Union 2002].

In Australia, regulations that apply to the more populous eastern States generally allow 11 or 12 hours of driving per day. In contrast, there are no hours-of-service regulations in remote, sparsely populated Western Australia. Instead, truckers and motor carriers in Western Australia are expected to operate under a Code of Practice for fatigue management. The

Code of Practice allows for long work hours (an average of 14 hours per day over 12 days), but it permits drivers to decide when they need to rest [Transport Western Australia 1998]. Although the Code of Practice addresses issues relevant to the U.S. transport industry, its effects on trucker safety have not yet been evaluated.

The FMCSA and Transport Canada are working cooperatively to develop and test another nonregulatory approach, the Fatigue Management Program. Educational components of the Fatigue Management Program that are designed to enhance drivers' trip planning will address wellness, lifestyle, sleep hygiene, and alertness. Other interventions include screening for sleep disorders and development of guidelines for dispatchers to improve scheduling practices. Two pilot tests have been conducted in Canada, with a similar test to be conducted in the United States in the near future. If the Fatigue Management Program is shown to be effective, it will be offered for implementation in both nations [FMCSA 2002b].

4.1.5 Noncompliance with Hours-of-Service Regulations

Research in the United States and Australia has reported rates of noncompliance with hours-of-service regulations ranging from 38% to 73% [Braver et al. 1992; Hartley 1997; Hertz 1991]. Economic pressures may encourage violations. In the United States, truckers' pay may be based on miles driven or value of cargo, which may increase incentive to violate the regulations. This method of compensation is prohibited in some European countries, including Sweden and France [FHWA 2000]. CMV drivers covered by Federal Motor Carrier Safety Regulations are exempt from the overtime provisions of the FLSA, and they are therefore not guaranteed pay for hours worked beyond 40 hours per week. In the absence of opportunity for overtime earnings, paying truck drivers by the mile can increase their incentive to drive additional hours, thereby increasing the likelihood of fatigue.

Compensation and the potential for fatigue are also linked with respect to nondriving tasks. During on-duty, nondriving time, truck drivers perform other tasks such as cargo loading and unloading, maintenance, and record-keeping. These nondriving tasks, particularly those involving physical labor, also contribute to fatigue. Although truck drivers may be paid an hourly or mileage rate for time spent driving, they may not be paid for the time they spend performing nondriving tasks. A recent survey of truck drivers found that 45% were paid for time spent loading and unloading, and 21% reported being paid for maintenance tasks [Belman et al. 1999]. Both these statistics have implications for safety. Lack of compensation may reduce the incentive for drivers to perform thorough safety inspections. In addition, it may increase the incentive to work too quickly during loading and unloading, thereby increasing the risk of injury from overexertion and fatigue.

An infrastructure issue that has been cited as a contributor to driver fatigue in both the United States and Australia is the shortage of suitable parking areas for drivers of large trucks to stop and rest [Braver et al. 1992; 64 Fed. Reg. 28237 (1999); FHWA 1999; Hartley 1997]. Demand for parking may be so great that truck stop owners may set time limits that make it difficult for drivers to get adequate rest. Participants at a Federal Highway Administration forum on the topic suggested that the use of alternative parking areas such as weigh stations and freight terminals be considered as a short-term solution [FHWA 1999].

Individual driver characteristics and work habits may contribute to driver fatigue and risk of a fatigue-related crash. These individual factors include age, individual differences in ability to adjust to irregular or extended work hours or night work, physical health and fitness, driving experience, undiagnosed sleep disorders, drug or alcohol consumption, and electing to drive for longer periods without taking a break [Brown 1995; NHTSA 1998a]. The importance of individual differences is underscored by research showing that small numbers of drivers contributed disproportionately to the total number of drowsiness episodes noted [Hartley 1997; Wylie et al. 1996]. However, these findings do not mean that the experience of fatigue is related only to individual driver characteristics. The unique working conditions of the trucking industry call for creative efforts to modify work schedules and ancillary on-duty task assignments so that drivers' opportunities for rest are more similar to those of workers in other professions. Such an approach may help motor carriers retain valued employees, ensure employment for qualified drivers, and enhance roadway safety.

4.1.6 Federal Research to Address Driver Fatigue

In response to these concerns, Federal agencies have sponsored or conducted the following research to provide a scientific basis for revising hours-of-service regulations in the motor carrier industry:

- A 1995 National Transportation Safety Board study reported that the three most important predictors of fatigue involvement in large truck crashes were the duration of sleep in the last sleep period before the crash, the total hours of sleep obtained in the 24 hours before the crash, and the presence of split sleep periods. Major recommendations from this study were to complete rulemaking within 2 years to (1) revise 49 CFR 395.1 to require sufficient rest provisions for drivers to obtain at least 8 hours of continuous sleep after driving for 10 hours or being on duty for 15 hours and (2) eliminate the portion of 49 CFR 395.1 that allows drivers with sleeper berths to split the 8 hours of required off-duty time into 2 separate periods [NTSB 1995].

- A 1996 Federal Highway Administration field study of commercial driver fatigue assessed 80 drivers who followed driving regimens that differed by length of time on duty (10 versus 13 hours), type of work shift (regular hours versus rotating hours), and start time (day versus night). Drowsiness was assessed through performance tests, physiologic tests such as electroencephalographs, and video recordings. The authors concluded that time of day (i.e., driving at night) was the most important predictor of fatigue—not number of hours driven or cumulative number of trips made. Highest levels of drowsiness were noted in the 8-hour period between late evening and dawn. However, it should be emphasized that drivers in this study got very little sleep on average: 3.8 to 5.4 hours per day, depending on their driving schedule. In addition, performance tests and self-assessments done as part of the study showed some evidence of cumulative fatigue. The authors concluded that insufficient opportunity for sleep and failure of drivers to place high priority on sleep were the key contributors to lack of sleep [Wylie et al. 1996].

- In 1999, the National Transportation Safety Board published a review of progress by DOT in addressing the Board's 1989 recommendations regarding operator fatigue. The Board reported that the DOT had made progress in implementing a coordinated research program on fatigue and had developed and disseminated educational materials about shift work to the transportation industry. However, the Board noted that little progress had been made in revising hours-of-service regulations to reflect the most current research findings on sleep and fatigue. This report restated the two 1995 recommendations for changes to 49 CFR 395.1 described above. It also recommended that the revised hours-of-service regulations should limit hours of service, provide for predictable work and rest schedules, and consider circadian rhythms and normal requirements for sleep and rest [NTSB 1999].

- In 2000, the FMCSA published results of a study of the effects of sleep on CMV driver performance. The first portion collected data on sleep patterns of long- and short-haul drivers over 20 days under normal work conditions. Both groups of drivers averaged about 7.5 hours of sleep per night. Short-haul drivers were more likely to have a single sleep period, while long-haul drivers obtained almost half their daily sleep during work hours, mostly in sleeper berths. The authors noted that drivers in both groups frequently had inadequate sleep during off-duty time [Balkin et al. 2000].

The laboratory portion of the study assessed performance on physiological, psychomotor, and driving simulation tests for 66 drivers assigned to 3, 5, 7, or 9 hours in bed each night over a 14-day period. For all but the group assigned to spend 9 hours in bed, test performance declined further with each successive day, even among the group that was assigned to spend 7 hours in bed. For the group assigned to only 3 hours in bed each night, performance did not return to baseline levels even after 3 consecutive nights with 8 hours in bed [Balkin et al. 2000].

4.1.7 Preventing Fatigue-Related Crashes

Federal regulations address fatigue in the motor carrier industry by specifying maximum hours of driving time and duty time and minimum hours of off-duty time. Yet, drivers in other industries have limited protections from work schedules that can lead to fatigue. Few studies have addressed driver fatigue among workers who operate company-owned or personal motor vehicles other than large trucks when performing their jobs. These driving environments are largely unregulated, especially those in which personal vehicles are used for work purposes. Thus, for employers not covered by the motor carrier regulations whose workers are expected to drive on the job, a driver fatigue management program is a critical element of the overall safety program.

4.2 SPECIAL ISSUES IN MOTOR CARRIER SAFETY

4.2.1 Other Safety Concerns

The highest priority of the FMCSA is to reduce the number of fatalities from crashes of large trucks by at least 50% from the 1998 baseline (5,374 deaths among truck drivers and other road users) by the end of 2009. Although the issue of driver fatigue is central to safety concerns about the motor carrier industry, numerous other factors related to the driver, the vehicle, the road, and the environment influence injury and fatality risk for truckers and other motorists. In its Safety Action Plan for the years 2000 through 2003, the FMCSA cited challenges to progress in improving safety in the motor carrier industry. These included the rapid growth in large-truck mileage and in the number of motor carriers, the need for resources to improve compliance reviews and the Commercial Driver's License Program, the need for additional research on causal factors in large-truck crashes, slow progress in rulemaking, and the need for further evaluation of collision avoidance technologies [FMCSA 2000]. In addition, characteristics of the broader roadway work environment (such as those discussed in the following subsections) affect the safety of long-haul truck drivers and others with whom they share the road.

4.2.2 Vehicle Safety and Design Issues

Vehicle safety standards for large trucks appear, in some instances, to be less protective than similar standards for passenger vehicles. For example, trucks with a GVWR greater than 10,000 lb are excluded from standards addressing protection of the head from interior impact, protection against impact from the steering control system in a crash, requirements for roof crush resistance over the passenger compartment, and requirements for head restraints to reduce frequency and severity of injuries that may occur in rear-end and other collisions [49 CFR 571, Standard Nos. 201, 202, 203, and 216].

The adoption of safety standards for trucks has lagged behind the adoption of similar standards for passenger vehicles.

In addition, the adoption of safety standards for large trucks has lagged behind the adoption of similar standards for passenger vehicles. For example, specifications to minimize the likelihood of inadvertent operation of powered windows, roof panels, and partitions went into effect in 1971 for passenger vehicles, but not until 1988 for trucks [49 CFR 571, Standard No. 118]. Another example is Standard No. 121, which applies to air brake systems. Originally implemented in 1975, this standard was struck down by a court decision in 1978. The standard's key performance requirements were not reinstated until 1997 [Krall 2002].

In some instances, safety protections for truck drivers have improved in the absence of regulatory change. The provisions of Standard No. 208 (Occupant Protection) that require installation of lap belts in heavy trucks went into effect in 1972. In response to research findings that three-point shoulder-belt restraint systems reduce the incidence of head and upper body injuries, truck manufacturers have voluntarily equipped trucks with these restraint systems since the late 1980s [Krall 2002].

Requirements for application of retroreflective sheeting or reflectors on large trailers and semi-trailers (incorporated into 49 CFR 393 in recent years) have yielded substantial safety benefits. Overall, the use of these materials on trailers reduced by 29% the incidence of other motorists' vehicles striking the rear or sides of semi-trailers under dark conditions. Retroflective sheeting was most effective in reducing injury-producing crashes (1) under dark conditions in which no additional lighting was present, (2) when the driver of the impacting vehicle was under age 50, and (3) when the material was used on a flatbed trailer [NHTSA 2001b].

4.2.3 Vehicle Maintenance

Research has linked inadequate maintenance to increased crash risk for large trucks.

Research has linked inadequate maintenance to increased crash risk for large trucks. An analysis of data from FARS and GES estimated that 4.5% to 5.0% of all CMV crashes have a mechanical component [Randhawa et al. 1998]. This study identified brakes, securing of loads, tires, and wheels or rims as the most common mechanical contributors. However, these results may underestimate the actual proportion of crash-involved trucks with mechanical defects. FARS and GES data are based on reports from law enforcement officers, who are generally not trained to identify vehicle defects. Furthermore, the amount of information about mechanical defects collected on police crash reports varies from State to State [Blower 2002; Randhawa et al. 1998].

Other studies using case-control design or in-depth investigative methods have reported considerably higher proportions of mechanical defects among crash-involved large trucks. A case-control study reported that large trucks with equipment defects were 1.7 times more likely to be involved in a crash than trucks with no defects [Jones and Stein 1989]. However, this study of crash-involved tractor-trailers matched with noncrash-involved controls from the same traffic stream found high proportions of equipment defects in both groups: 76% for the crash-involved trucks and 66% for the controls. The defects were serious enough in 41% of the crash-involved trucks and in 31% of the controls that these trucks should have been removed from service. A more recent study of crashes in Michigan found that nearly 55% of trucks involved in fatal crashes had at least one defect related to the truck's mechanical condition [Blower 2002]. This study reported that 28.5% of trucks had at least one out-of-service condition—that is, a defect serious enough to require that the truck be parked until the defect was corrected.

Brake defects were found in 56% of the crash-involved trucks in the study by Jones and Stein [1989], and steering equipment defects were found in 21%. Furthermore, the authors were able to demonstrate a relationship between the type of defect and the crash configuration: 50% of trucks that rear-ended other vehicles had out-of-service brake defects, and 10% of trucks that sideswiped other vehicles had steering defects. A related publication noted that 23% of the controls with equipment defects had been on the road for less than 2 hours, suggesting that these defects were likely to have been present at the beginning of the trip and should have been identified in a pre-trip inspection [Jones and Stein 1987].

Compared with Jones and Stein [1989], Blower [2002] found lower proportions of brake violations (34.5%) and steering defects (5.6%). Like Jones and Stein, Blower found that the crash configuration and type of defect were related. Brake defects were associated with incidents in which the truck was the striking vehicle in a rear-end collision: 27.3% of trucks that were struck from the rear had a brake violation, compared with 50.0% of trucks that were the striking vehicle [Blower 2002]. This study also examined fatal crashes in which a vehicle crossed the center line and struck another vehicle. The trucks that crossed the center line were more likely to have brake defects (46.7%) than trucks that were struck by another vehicle that crossed the center line (19.7%). Similarly, trucks that crossed the center line were much more likely to have steering defects (26.7%) than trucks that were struck by another vehicle that crossed the center line (2.8%).

Defective lights and signals (found in 23.7% of large trucks involved in fatal crashes) were the second most common type of vehicle defect reported by Blower [2002]. These violations were more common in crashes in which trucks were struck from the rear (40.0%) than in crashes in which the truck was the striking vehicle (15.4%), suggesting that approaching vehicles were unable to see these trucks [Blower 2002].

4.2.4 Crash Location, Highway Design, and Emergency Response

For large trucks, crash risk on interstate highways is relatively low compared with U.S. and State highways. One study of FARS data estimated that interstate highways accounted for 40% of truck miles driven in 1996 but only 23% of truck-related fatal crashes [Stuster 1999]. This difference may be due partly to the more consistent speeds on interstate highways and to the relatively small number of access points that provide advance warning of entry and exit options. In contrast, U.S. and State highways may have numerous access points to allow local traffic to enter and exit, and these may not be as well marked as they are on interstate highways. Where there is a high volume of CMVs such as large trucks using the same road, the risk of CMV crashes with passenger vehicles increases. This traffic situation on U.S. and State highways, with their greater speed differentials, more frequent braking and accelerating, and greater number of access points, requires greater vigilance on the part of CMV operators and greater appreciation of CMV operating capabilities by passenger vehicle drivers. Limiting the number of highway entrance and exit ramps is a component of Dutch transportation policy. In some areas of the Netherlands, "truck-only" lanes are being designed and tested to reduce conflicts between trucks and passenger vehicles [FHWA 2000].

Large-truck crashes occur disproportionately in rural areas, a fact that is consistent with the high proportion of these crashes that occur on interstate, U.S., and State highways (see Table 4). The rural location of many large truck crashes has implications for response by emergency medical services as well. In 2000, 16% of large-truck crashes were single-vehicle events [NHTSA 2001a]. Emergency medical services personnel may have to travel a greater distance to reach the scene of a rural crash: they were able to respond within 10 minutes of notification for 56% of fatal rural crashes in 2000, compared with 89% of urban crashes [NHTSA 2001a]. Extrication of injured truck occupants may be complex and prolonged in rollover and jackknife events in which loads may have shifted, doors may be jammed, and the cab area may be deformed [Baker et al. 1976]. When a passenger vehicle strikes the rear of a large truck, extrication of the passenger vehicle occupant may be complicated if the vehicle has underridden the truck.

4.2.5 Research Addressing Large-Truck Safety Issues

The FMCSA is conducting or sponsoring a variety of research projects that may ultimately make large trucks inherently safer and may help motorists and truckers drive near one another more safely. The Intelligent Vehicle Initiative features collaboration with vehicle manufacturers to develop electronic brakes, on-board sensing of safety-critical systems, devices to improve truck stability, collision warning devices, and hazard location technologies [FMCSA 2000]. Other research under the Intelligent Vehicle Initiative includes a study to identify human factors and possible countermeasures for CMV rear-end collision avoidance and lane changing, and an instrumented vehicle study of car-truck interaction to describe the actions of other vehicles around trucks. These two studies could contribute information essential for developing training programs for truckers and public education programs directed toward motorists. In addition, the information collected about driving behaviors of other motorists around large trucks may help refine collision warning systems.

The FMCSA, in cooperation with NHTSA, initiated the multiyear Large Truck Crash Causation Study in 2002. This study uses sites already used for collection of Crashworthiness Data System and GES data to investigate at least 1,000 large-truck crashes that result in fatality or serious injury. Teams made up of Crashworthiness Data System researchers and State truck inspectors will collect detailed data on the crash, vehicles, and occupants. Assessment of these data will help determine the critical event that made a collision unavoidable and the reasons for the critical event [Craft and Blower 2002].

4.2.6 Future Plans

Future rulemaking by the FMCSA is slated to address training requirements for entry-level drivers and unique training needs of multiple-trailer combination vehicle drivers. The agency is also planning to study the relationship between driver payment methods and safety [FMCSA 2000].

4.3 DRIVER DISTRACTION AND CELL PHONE USE

Driver distraction has been defined as "capture of the driver's attention by information that is irrelevant to the driving situation to a degree where insufficient information is left for the primary task" [Janssen 2000]. Some distractions affect the driver by requiring physical maneuvers that may threaten vehicle control, whereas others are mental distractions from sources inside or outside of the vehicle. Among all the elements of driver distraction, cell phone use has perhaps received the most attention. In recent years, cell phone ownership has increased rapidly in the United States, with more than 137 million cell phone subscriptions as of August 2002 [Cellular Telecommunications & Internet Association 2002]. Cell phone use while driving has been questioned because it may contribute to increased risk of motor vehicle crashes. Despite this safety concern, the availability of a cell phone in a vehicle offers a number of benefits, including prevention of unnecessary trips, peace of mind through improved access to family and friends, the ability to report emergencies, improved response time to accidents, and the ability to handle household errands during commuting time [Brookhuis et al. 1991; Lissy et al. 2000]. For workers, the availability of a cell phone may offer increased productivity, efficiency, and access to clients and coworkers [Lissy et al. 2000].

Cell phone use while driving has been questioned because it may contribute to increased risk of motor vehicle crashes.

4.3.1 Data on Crashes Involving Cell Phone Use While Driving

National estimates from NHTSA observational studies conducted during 2000 indicate that at any given time during daylight hours, 3% of passenger vehicle drivers in the United States were actively using a hand-held cell phone. An additional 0.9% of drivers were estimated to be using a hands-free phone [Utter 2001]. However, no estimates exist for the number of persons who use cell phones while driving for work. Although improper use of cell phones and other devices has been documented as contributing to roadway crashes in the general population, determining the role of cell phones in work-related crashes is difficult. CFOI, the primary source of data on occupational fatalities, does not collect this information. FARS collects information about the presence of driver-related factors such as inattention, drowsiness, and cell phone use, but it is less comprehensive than CFOI in its coverage of occupational roadway crashes. Death certificates are the only means FARS uses to ascertain work relationship; and although death certificates are the single source shown to identify the greatest number of work-related deaths, at least 20% may not be captured [Stout and Bell 1991].

Currently only 15 States are required by law to collect information about cell phone involvement on police crash reports.

The fundamental problem is that currently only 15 States are required by law to collect information about cell phone involvement on police crash reports [Rushing 2002]. Therefore, although FARS and the National Automotive Sampling System added cell phone use as a driver-related factor in 1995, the police crash reports that are a primary source of data for these systems do not necessarily collect this information [NHTSA

1997]. Even for States that do collect it, the true extent of the involvement of driver distraction and cell phones may be underestimated: as with fatigue-related crashes, assessment of these elements is largely subjective. And police crash reports are not designed to provide a scientific assessment of crash causation.

Although DOT data systems provide a mechanism to collect national data on roadway crashes associated with cell phone use, published data indicate that very small numbers are actually reported through FARS—a total of 76 cell-phone-related fatal crashes in 1994 and 1995 [Lissy et al. 2000]. Examination of more recent on-line FARS data revealed that 81 fatal crashes in 1999 and 101 fatal crashes in 2000 were reported to be related to cell phone use—0.2% of the total for those years. One of the crashes in 1999 and two of the crashes in 2000 were identified as being a fatal injury at work [NHTSA 2002b]. Other electronic devices (e.g., computers, fax machines, and on-board navigation systems) were identified as contributing to a total of five fatal crashes in 1999 and 2000, one of which was a fatal injury at work. It is not yet known whether the small number of fatal crashes related to use of cell phones or other electronic devices reflects under-reporting or whether these devices indeed pose little risk [NHTSA 1997].

Data from the Crashworthiness Data System indicate that in 1995, small proportions of nonfatal towaway crashes in the United States were related to cell phone use. Of nearly 2.4 million crashes in 1995, talking on a cell phone was associated with 0.1%, and dialing a cell phone was associated with an additional 0.1% [Wang et al. 1996]. Unlike FARS, the Crashworthiness Data System does not collect information about work relationship. However, this system does record a detailed description of the vehicle and information about gross vehicle weight, both of which may be of some value in assessing whether a crash is occupational in nature.

Lissy et al. [2000] suggest that fatal cell phone-related crashes may appear infrequently in data systems that focus on fatal crashes and towaway crashes because they are likely to occur during rush hours, when congestion may lead to lower-speed collisions and hence fewer crashes resulting in fatalities and injuries. In addition, cell phone use may be most common during daytime hours, when overall crash risk is lower.

4.3.2 Research on the Risks of Cell Phone Use While Driving

Two case-control studies found a statistical but not necessarily causal relationship between cell phone use and increased risk of motor vehicle crashes [Violanti and Marshall 1996; Violanti 1998]. The methods used in the first of these studies did not allow researchers to establish whether a cell phone was in use at the time of the collision. A study by Redelmeier and Tibshirani [1997] is generally considered to be the most scientifically sound study of the relationship between cell phone use and crash risk. They examined drivers involved in property-damage-only crashes, comparing their cell phone use on the day of a crash with their cell phone use on the day before the crash during the same time period. This research found that drivers who had used a cell phone in the 10 minutes before a crash had 4.3 times the crash risk of those who had not. This study, like several others, was limited by its inability to establish that cell phone use caused the crash.

The use of cell phones while driving has a negative effect on driving performance.

In general, studies conducted in driving simulators and in instrumented vehicles have found that the use of cell phones while driving has a negative effect on driving performance [Brookhuis et al. 1991; McKnight and McKnight 1993; Nilsson and Alm 1991; Tijerina et al. 1995]. In these studies, the decreased performance associated with cell phone use was measured by decreased response time for manual or cognitive tasks, decreased time looking at the road, increased workload (as indicated by increased heart rate and steering wheel movements), less mirror checking, longer braking times, failure to maintain safe following distances or consistent speed, and poor lane-keeping.

Results are mixed from research addressing whether hands-free phones with voice-activated dialing pose less risk than hand-held phones that require manual dialing. In general, research suggests that hands-free phones are safer than hand-held models, although they still pose distractions for drivers [Stevens and Paulo 1997]. One study conducted with instrumented vehicles found that drivers using hands-free cell phones performed better than those using hand-held phones but less well than those who did not use cell phones at all [Brookhuis et al. 1991]. A study conducted in a driving simulator reported better driving performance for voice-activated dialing versus manual dialing [Serafin et al. 1993]. In contrast, another simulator study found equivalent declines in driving performance among users of hand-held and hands-free cell phones [Strayer and Johnston 2001].

Studies outside the laboratory, like simulator-based studies, have failed to establish that hands-free phones offer clear safety advantages.

Studies outside the laboratory, like simulator-based studies, have failed to establish that hands-free phones offer clear safety advantages. A study of professional semi-truck drivers found that lane-keeping was improved and distraction from visual driving tasks was reduced during voice-activated versus manual dialing [Tijerina et al. 1995]. In contrast, two other studies did not report lowered crash risk for users of hands-free phones versus hand-held phones [Dreyer et al. 1999; Redelmeier and Tibshirani 1997]. However, it is important to note that the two types of studies are not directly comparable. The first study [Tijerina et al. 1995] measured differences in performance that may be associated with crash risk but was not designed to follow drivers' crash experience. The other two studies reported differences in crash risks among large groups of cell phone users [Dreyer et al. 1999; Redelmeier and Tibshirani 1997].

Also unclear is whether crash risk is greater while dialing, conducting a conversation, or reaching to answer a phone or retrieve a dropped phone. Studies done in the United States have generally found that conversation, not dialing, is involved in greater numbers of cell-phone-related crashes. A multiyear review of North Carolina police crash reports found that reaching for a dropped cell phone and talking on a cell phone were the primary circumstances associated with crashes involving cell phones [NHTSA 1997]. A review of FARS and GES cases found that talking on a cell phone was implicated in 17 of 28 crashes involving cell phones (61%). Reaching for a phone was identified in two cases, and dialing was identified in only one case [NHTSA 1997]. Another study, conducted in a simulator, assessed differences in driving performance among users of hand-held cell phones given simple versus more complex conversational tasks. The researchers reported that more driving errors were committed while performing a more complex word-generation task than during a simple word repetition task [Strayer and Johnston 2001]. These findings have implications for the safe use of cell phones in the workplace. Although little is known about the content of work-related cell phone calls made from vehicles, it is reasonable to assume that some of these calls place substantial demands on driver attention and may increase crash risk.

4.3.3 In-Vehicle Internet and Other Information Systems

New technologies have the potential for further eroding driver attention, especially when they are coupled with cell phone use while driving. Although in-vehicle Internet technology would ideally provide information that has positive effects on traffic and fleet management [Burns and Lansdown 2000], others have cautioned that little is known about the effects of multiple information systems on driver attentiveness [NHTSA 1997]. Trends toward miniaturization of electronic devices might also compromise safety by placing greater visual demands on the driver [NHTSA 1997].

Little is known about the effects of multiple information systems on driver attentiveness.

A recent study conducted on a test track assessed the effects of multiple devices on driver performance [NHTSA 2000a]. Drivers were asked to manually tune a car radio, manually dial an unfamiliar number on a cell phone, and enter information into a route guidance system. The route guidance systems tested had various types of user interfaces: manual keypad entry, joystick, and voice activation. Overall, drivers needed much more time to interact with the route guidance system than to dial the cell phone or tune the car radio.

Compared with drivers aged 35 or younger, drivers aged 55 or older took more than twice as long to enter information into the route guidance system, took their eyes off the road about twice as often, and had much more difficulty staying in the travel lane while entering information. For all drivers, using the voice-activated route guidance system was associated with far less time with eyes off the road and no declines in lane-keeping. Among older drivers using the voice-activated system, times with eyes off the road decreased almost to that observed among younger drivers. The voice-activated system did not necessarily require less time than interacting with the manual entry systems. However, the eyes-off-the-road time associated with its use was much lower—nearly as low as that observed for dialing a cell phone or tuning a radio. Thus voice-activated route guidance systems appear to be preferable to manual entry systems, although research is needed to further assess the effects of voice interaction on driver attentiveness [NHTSA 2000a].

The potential for task and sensory overload as a result of more and smaller devices is of particular concern in the workplace, where installation of Internet-based information systems may offer increased productivity through streamlined customer contact and scheduling. Given the potential economic benefits, it is possible that introduction of this technology into fleet vehicles may precede its widespread use in personal vehicles. Thus the first evidence of any safety effects of in-vehicle Internet combined with other technologies may be seen among workers.

The European Union has developed principles for in-vehicle Internet systems that address design, installation, presentation of information, and drivers' interactions with displays and controls [Commission of the European Communities 2000]. The European Union principles stress the importance of maintaining the driver's attention to the driving task, view of the road, and view of critical vehicle displays and controls. In addition, they emphasize that in-vehicle Internet systems should not (1) place the driver under pressure to respond in a certain time frame, (2) require long, uninterruptible sequences of interactions, or (3) visually entertain the driver. Others have recommended that in-vehicle Internet systems be capable of automatically restricting information when traffic conditions demand it [Burns and Lansdown 2000].

4.3.4 Policy and Legislative Issues Related to Cell Phone Use While Driving

Policy decisions to guide cell phone use while driving are unusually difficult given that cell phones offer clear safety benefits along with risks. In addition, the rapid growth in cell phone ownership has not been accompanied by regulations governing their use, either in the general population or in the workplace. Between 1995 and June 2002, at least 41 States considered legislation addressing the use of cell phones and other in-vehicle electronic devices in passenger vehicles [Rushing 2002]. To date, no State has instituted a complete ban on cell phone use while driving. However, the State of New York passed legislation (effective in December 2001) that prohibits motorists from using hand-held cell phones while driving on public roadways. A number of localities have passed similar ordinances prohibiting the use of hand-held devices [Rushing 2002]. An additional concern is that varying restrictions on cell phone use by locality has the potential to create confusion among residents and among those who are in an unfamiliar location on business travel and unaware of local laws. As of June 2002, five States had passed legislation that would make State law override any local ordinances related to cell phones. However, to date only New York has acted to place significant restrictions on the use of cell phones statewide [Rushing 2002].

Of concern to employers is the possibility of increased legal liability of workers (and perhaps employers) who are involved in cell-phone-related crashes. One source cited recommendations that employers consider placing limits on worker cell phone use and convey to workers that cell phone use is not a necessary condition of employment [Buschman 2000]. To date, no research studies have addressed cell phone use on the job, including whether pressure on workers to use cell phones for conducting business has a detrimental effect on vehicle safety.

4.4 AGE-RELATED FACTORS

4.4.1 Young Drivers

Workers aged 16 and 17 have lower fatality rates attributable to work-related roadway crashes than do workers aged 18 and 19 (which may reflect lower levels of exposure to driving because of FLSA prohibitions). However, these workers are still exposed to crash risks as vehicle passengers and as pedestrians. Fatality rates among workers aged 18 and 19 (those not restricted under FLSA) are comparable with those for adult workers aged 20 to 44, and rates for workers aged 18 are higher than those for workers aged 35 through 44 (see Tables 7 and 8).

Several factors contribute to the increased crash susceptibility of young drivers. Numerous studies indicate that young novice drivers may acquire vehicle handling skills quickly, but they require much more time to develop higher-order perceptual and cognitive skills needed to recognize hazards and respond appropriately [Deery 1999; Pelz and Krupat 1974; Regan et al. 1998b]. Novice drivers may also lack skills for determining what factors in the driving environment require their attention at a given time, adjusting to differences in intensity of the driving workload and matching their performance to demands of the task [Deery 1999].

Novice drivers may acquire vehicle handling skills quickly, but they require much more time to develop skills needed to recognize hazards and respond appropriately.

Immaturity is another important factor. Young drivers typically possess less well developed judgment, engaging in more risky driving behaviors than their more experienced adult counterparts [Deery 1999]. Also related to immaturity is the tendency for young drivers to overestimate their own driving skills [Gregersen 1996]. Another contributor to injury risk is low levels of safety belt use among adolescents and young adults compared with older persons [NHTSA 1998b]. Sixty-one percent of vehicle occupants aged 16 to 20 who died in automobile or truck crashes in 2000 were not wearing a safety belt [NHTSA 2001a].

Fatigue may also contribute to crash risk for young workers who drive on the job. Lifestyle factors can result in insufficient sleep for adolescents at a time when maturational changes can make them more susceptible to the effects of fatigue [NHTSA 1998a]. Employed youth, who must balance school, home, and social life with job responsibilities, typically get less sleep than their counterparts who are not employed, and they are more likely to report daytime sleepiness [Carskadon 1990].

Graduated driver licensing laws, now in place in many States, provide novice drivers the opportunity to gain additional driving experience before full driving privileges are extended to them. Features of graduated driver licensing laws vary from State to State. Most, however, provide for a gradual progression from the learner's permit stage to full licensure, extending the length of time during which novice drivers can gain skills and driving experience. Some require that novice drivers log a minimum number of supervised driving hours. Most graduated driver licensing programs have zero tolerance for illegal drugs or alcohol. Many limit night driving as well as the number of teenage passengers. In New Jersey, the graduated driver licensing law prohibits permit holders who have not yet passed the road test required for initial licensure from using a cell phone or other wireless communication device while operating a vehicle [Assembly of the State of New Jersey 2001].

Many of the risk factors that increase the likelihood that younger drivers in the general population will be involved in vehicle crashes are also present in the workplace. Young drivers are not only new behind the wheel, but their newness to the workplace compounds occupational safety concerns for a population that is already at high risk for vehicle crashes.

Young drivers' newness to the workplace compounds occupational safety concerns for a population that is already at high risk for vehicle crashes.

Federal regulations under the FLSA address vehicle safety concerns for young workers by prohibiting all on-the-job driving for 16-year-olds and placing limitations on the nature and amount of driving permitted for 17-year-olds (see Section 3.4.1). However, the FLSA does not cover young workers aged 18 and older, who are still in the process of developing driving skills and gaining experience. For this group of inexperienced young adult drivers, employers should consider postponing the assignment of intensive or time-sensitive driving tasks, thereby continuing to act in the spirit of both the FLSA and graduated driver licensing laws.

Research is now under way to develop driver training modules designed to improve skills that may be underdeveloped in young drivers. Many of these have been tested successfully in driving simulators but have yet to be evaluated outside the laboratory. One example is insight training, which is intended to make young drivers more aware of the unpredictability of typical driving situations and the limitations of their own skills [Gregersen 1996]. Another is variable priority training, which involves assignment of multiple tasks unrelated to driving, with the goal of improving novice drivers' skills in dividing their attention between competing tasks and priorities [Regan et al. 1998a]. Other approaches seek to improve young drivers' ability to (1) apply what they have learned to increasingly complex and dissimilar situations, (2) improve their ability to predict a sequence of events, and (3) evaluate their own performance and perceive hazards better by describing their thought processes to an instructor while actually driving [Deery 1999; Regan et al. 1998b]. If field testing of these approaches is successful, they may eventually be incorporated into driver training programs. Employers should consider implementing programs that use innovative teaching methods tailored to younger drivers, as they may be particularly useful in remedying potential deficiencies among this group.

4.4.2 Older Drivers

The need to accommodate older drivers is receiving increasing attention in the traffic safety community at large. As increasing numbers of Americans continue to work beyond the traditional retirement age of 65, the special needs of older drivers become a workplace safety issue as well. Older drivers have two traits in common with younger drivers: difficulty in responding to traffic hazards and a tendency to overestimate driving skills [Gregersen 1996; Holland 1993]. However, the reasons for these traits differ for the two age groups. Younger drivers may be at increased risk for crashes because they do not have enough experience to recognize, assess, and respond to hazards, and because they may be willing to accept higher levels of risk [Deery 1999]. With older drivers, the issue is not necessarily a lack of knowledge about what constitutes a hazard. Instead, the danger is that they may not anticipate and react to hazards quickly enough. Furthermore, they may not recognize their failure to deal with these situations as effectively as they did in the past [Holland and Rabbitt 1994]. Although their understanding of what is required may not decline, their ability to respond appropriately in a real-world driving situation may diminish.

Both younger and older drivers tend to overestimate their driving skills relative to other persons of their age [Gregersen 1996; Holland 1993; Pelz and Krupat 1974]. However, older drivers may overestimate their skills because of a decreased ability to react to high-risk situations—not from lack of knowledge about the risk (which is more likely to be the case among younger drivers). Older drivers report compensating for what they perceive to be high-risk situations by avoiding rush-hour driving, complex traffic situations, night driving, and long trips [Holland and Rabbitt 1994]. Avoiding such situations may not be an option for commercial drivers and others who drive for work.

Reduced reaction times (both physical and cognitive), reduced ability to divide attention between tasks, and increased difficulty in handling complex and unfamiliar situations are associated with the normal aging process and are widely recognized and well documented in the scientific literature [Brouwer et al. 1991; Holland and Rabbitt 1994; Maycock 1997; Stelmach and Nahom 1992]. In addition, normal aging results in declining visual acuity from reduced field of vision, less effective peripheral vision, and reduced ability to cope with glare from oncoming headlights and other sources [FHWA 2001; Maycock 1997]. The reduced range of head and neck motion associated with the normal aging process may also diminish the driver's skill in scanning the driving environment [FHWA 2001]. Night driving poses particular risks for older drivers. Night vision depends on seeing contrasts between objects, not on visual acuity alone, and this sensitivity to contrasts decreases with age [Burnham and Abrams 1998].

Certain driving situations and maneuvers may increase the crash risk among older drivers. Intersections are problematic for older drivers, especially where they must make decisions about yielding the right of way [Maycock 1997]. Older drivers may have trouble interpreting pavement markings and reading street signs [FHWA 2001]. They also have difficulty negotiating interchanges. For example, those who are cited at freeway interchanges are most often cited for failure to yield and improper use of lanes [FHWA 2001]. Situations such as highway construction zones may be particularly hazardous, since older drivers may not react quickly enough to signs, traffic control devices, decreases in lane width, and lane closures and shifts. Construction zones may also be problematic for older drivers because they violate drivers' expectations of how the roadway will be laid out.

Methods for assessing an older driver's fitness to continue driving on or off the job should ideally draw on the expertise of various safety and health professionals. Some researchers have concluded that general medical screening alone is not sufficient to identify older persons who can no longer safely operate a vehicle; they believe that tests of cognitive functioning can more effectively identify older drivers who may be impaired [Johansson et al. 1996; Lundberg et al. 1998]. Other researchers have focused on developing new methods to evaluate older drivers' visual perception skills, proposing that simple tests of visual acuity alone cannot reliably assess the ability to process the complex visual information needed for safe driving [Ball et al. 1988]. Related studies have shown that poor performance on more sophisticated tests of visual performance were highly predictive of crash involvement among drivers aged 55 to 90 [Ball et al. 1993; Ball and Owsley 1993; Owsley et al. 1998]. These tests assessed visual processing speed, ability to divide attention between centralized and peripheral objects, and ability to pay attention selectively in the presence of target objects and distractions.

As the number of older workers increases, so will the number of older workers who drive on the job.

As the number of older workers increases, so will the number of older workers who drive on the job. Employers will increasingly need to evaluate methods for giving older drivers continued opportunities for employment while ensuring that safety is not compromised. For many older persons, giving up driving is a life-changing event associated with a loss of independence and competence. However, employers will inevitably face the prospect of limiting or revoking driving duties of valued older workers. Such decisions should be made objectively after evaluating cognitive and visual ability and current levels of driving performance. Occupational medicine professionals, geriatric health professionals, and specialists in vision screening can help employers ensure that their medical screening programs effectively identify older drivers who may have trouble performing their duties safely. If it becomes necessary for an older worker to give up driving, employers should ideally make every effort to reassign the worker to nondriving duties that he or she can safely perform.

4.5 FLEET SAFETY ISSUES

Although workers employed in the transportation industry (which includes motor carriers) experience the greatest numbers of occupational fatalities because of vehicle-related roadway crashes, fully two-thirds of these occupational fatalities occur in industries other than transportation. In contrast to the unique regulatory climate in which the motor carrier industry operates, employers in other industries are governed by relatively few regulations specific to the operation of motor vehicles. The first of the prevention measures that are listed in Section 5.1 are intended to address fleet safety in these less regulated industries, but many are also relevant to the motor carrier industry. Conversely, numerous safety measures that are required for the motor carrier industry may be of value in other industries.

Mandatory use of seat belts is the single most important driver safety policy that employers can implement and enforce.

Mandatory use of seat belts is the single most important driver safety policy that employers can implement and enforce. NHTSA estimated that in 2000, the use of seat belts prevented 11,889 fatalities in the United States and could have prevented 9,238 fatalities that did occur [NHTSA 2002a]. Seat belt use by front seat occupants reduces the risk of fatality by 45% for passenger car occupants and by 60% for light-truck occupants [NHTSA 2000b]. NHTSA also determined that nearly 143,000 moderate to severe injuries could have been prevented had all vehicle occupants worn seat belts [NHTSA 2002a]. As of February 2001, approximately 70% of vehicle occupants wore seat belts. Although no data are available to distinguish between belt use on or off the job, it is clear that nonuse of seat belts has substantial direct and indirect impact on employers.

As with any workplace safety policy, driver safety policies such as mandatory use of seat belts can be effective only if employers (1) tell workers how important the issue is to the company and (2) enforce safety policy with fairness and vigilance. High proportions of drivers in the general population report that they are more attentive to safe driving practices than the average driver, thus drivers may view safety messages as meant for someone else [Williams et al. 1993]. Delivering information about safe driving practices alone may not be sufficient to motivate workers to drive safely. Employers may need to provide additional motivation by (1) emphasizing the potential catastrophic consequences of a motor vehicle crash to both worker and family, and (2) clearly communicating that safety infractions will not be tolerated [Kedjidjian 1994; Lin and Cohen 1997; Williams et al. 1993].

5 STRATEGIES FOR PREVENTING WORK-RELATED ROADWAY CRASHES

The prevention strategies described in this chapter are both broad and diverse, reflecting the large number of stakeholders with influence and interest in work-related roadway safety. Some of these strategies are supported by research results, injury data, or field testing, whereas others are offered for consideration and further research. They represent a compilation of proven and promising prevention strategies relevant to employers, workers, manufacturers, government agencies, transportation planners, and safety professionals. If implemented, these strategies can complement the effectiveness of existing standards and regulations.

5.1 GENERAL FLEET SAFETY

5.1.1 Employers

- Provide fleet vehicles that offer the highest possible levels of occupant protection in the event of a crash. In addition to reducing injury severity in the event of a crash, this practice also conveys to workers that vehicle safety is a company priority. (Information about the crashworthiness of a given vehicle make and model is available on the NHTSA Web site at http://www.nhtsa.dot.gov).
- Implement a comprehensive vehicle maintenance program that includes pre-trip vehicle inspections for key potential problem areas, immediate withdrawal from service for any vehicle with mechanical problems, and periodic withdrawal from service for comprehensive inspection and scheduled maintenance. Federal motor carrier regulations under 49 CFR 396 contain a list of CMV systems and parts that must be inspected. In addition, the Commercial Vehicle Safety Alliance (an organization of officials responsible for enforcement of motor carrier safety laws) has developed out-of-service criteria that may be applied to

all types of fleet vehicles [Randhawa et al. 1998]. (Note: These criteria are limited to severe deficiencies and should not be used as sole maintenance criteria.)

- Develop delivery schedules that take into account the need for periodically taking trucks out of service for scheduled maintenance.
- Ensure that no worker is assigned to drive on the job if he or she does not have a valid driver's license. The license should be appropriate for the type of vehicle to be driven.
- Maintain complete and accurate records of workers' driving performance. In addition to checks of driving records of prospective employees, periodic rechecks after hiring are critical. Employers can also consider requiring drivers to provide periodic documentation of vehicle insurance and to report license suspensions or revocations as well as convictions for vehicle-related offenses. By law, employers of CMV drivers must review their driving records annually [49 CFR 391.25], but similar reviews are appropriate for other workers who drive on the job.
- Implement and enforce mandatory seat belt use policies.
- Communicate to workers that a violation of company driver safety policy is as serious as (and has similar consequences to) a violation of safety policy on the employer's premises.
- Where practical, consider adopting a "one driver, one vehicle" strategy. Assignment to a single vehicle instills a sense of responsibility and ownership. Also, a worker who operates the same vehicle each day may more easily identify potential mechanical problems with that vehicle [Heath 1996].
- Establish schedules that allow drivers to obey speed limits and follow hours-of-service regulations, where they apply. This recommendation pertains both to workers who drive long distances and to those who make local deliveries.
- Consider implementing driver safety programs that emphasize the link between driver safety at work and driver safety at home. Safe driving in the workplace benefits the worker's family by reducing the risk of fatality or disabling injury. In addition, lessons learned on the job can increase workers' awareness of the importance of safe driving outside of work hours.
- Ensure that workers receive the training necessary to operate specialized motor vehicles or equipment. This training should address changes in vehicle performance under different conditions. Examples include proper

operation of vehicles with anti-lock braking systems under differing weather conditions or changes in vehicle stability, depending on the size of the load.

- Require newly hired workers to attend performance-based defensive driving courses, with mandatory refresher training at regular intervals.

5.1.2 Workers

- Use safety belts while driving on or off the job.
- Before driving a rental car or other unfamiliar vehicle, familiarize yourself with the vehicle controls.
- If possible, map out the route in advance when driving in unfamiliar places.

5.2 FATIGUE-RELATED CRASHES

5.2.1 All Employers

- Incorporate fatigue management into safety programs. Consider adopting nonregulatory approaches (e.g., the Fatigue Management Program under development at FMCSA, or similar programs) if they are found to be effective.
- Provide drivers with detailed information about company policies related to driver discretion in scheduling start times, delivery times, and rest breaks. Employers covered by motor carrier regulations should permit drivers a reasonable degree of latitude in their work schedules to allow them to take rest breaks when they feel fatigued.
- Avoid requiring workers to drive irregular hours or to extend their workday far beyond their normal working hours as a result of driving responsibilities.

5.2.2 Motor Carrier Employers

- Establish schedules that allow drivers to obey speed limits and follow applicable hours-of-service regulations [NIOSH 1998].
- Nondriver workers with responsibilities for scheduling, dispatching, or supervising drivers should know and comply with regulations that govern scheduling [49 CFR 392.6] and hours of service [49 CFR 395.3].
- Support modifications in delivery schedules when necessary to ensure that drivers get adequate rest [Hartley 1997].

- Minimize the amount of time drivers must spend loading and unloading cargo. This may reduce risk of overexertion injuries (e.g., because of lifting) and may also reduce fatigue.
- Consider installing electronic on-board recorders to monitor compliance with hours-of-service regulations, given that research has shown widespread violation of these regulations in the United States. In the European Union, mechanical tachographs have been required since 1985 and are used to track driving time, time spent doing maintenance and administrative work, on-duty waiting time, rest time, and break time [FHWA 2000].

5.2.3 Policy Makers

- Support field studies to determine the safety consequences of revised FMCSA hours-of-service regulations that will apply to property-carrying CMV drivers beginning January 4, 2004.
- Encourage Federal and State agencies that provide rest areas for truck drivers to coordinate their efforts and ensure that adequate numbers of parking spaces are available. These entities should also coordinate with the private sector as appropriate. Drivers who must spend off-duty periods on the road should have access to secure rest areas located at regular intervals.

5.2.4 Transportation Planners and Traffic Engineers

- Recommend wider use of shoulder rumble strips to alert drivers that they have left the roadway. Research suggests that shoulder rumble strips placed on high-speed, controlled-access rural roads reduce the number of run-off-the-road crashes by 30% to 50% [NHTSA 1998a].

5.3 LARGE-TRUCK CRASHES

5.3.1 Safety Professionals

- Incorporate information about safely sharing the road with trucks and other large CMVs into driver education courses, State driver's manuals, and workplace driver training programs. The Share the Road Safely Campaign offers safety materials that can be used to supplement driver training (see www.sharetheroadsafely.org).
- Incorporate into truck driver training programs information about common unsafe driving practices of motorists in the vicinity of large trucks [Stuster 1999].

5.3.2 Motor Carrier Employers

- Consider compensating truck drivers for time spent on required safety inspections to increase their incentive to perform them thoroughly. This recommendation applies to drivers who are paid by the mile as well as those who are paid by the hour.

5.3.3 Transportation Planners and Traffic Engineers

- Assess whether the number of access points to State and U.S. highways might be reduced to minimize the number of situations in which CMVs and local passenger vehicles entering the stream of traffic may collide. Entrances and exits should be clearly marked and placed so that all highway users have optimum visibility of other vehicles.

5.4 CRASHES RELATED TO CELL PHONE USE AND DISTRACTED DRIVING

5.4.1 Workers

No preventive measures have been developed specifically for workers because research is lacking on cell phone use during work-related driving. However, preventive measures for the general driving public are also relevant to the workplace and are recommended for workers as follows [Buschman 2000; Lissy et al. 2000; Stevens and Paulo 1997]:

- Avoid placing or taking cell phone calls while operating a motor vehicle, especially in inclement weather, unfamiliar areas, or heavy traffic.
- Place calls from a stopped vehicle if at all possible.
- Allow a passenger, not the driver, to handle phone calls if possible. Alternatively, allow incoming calls to roll over to voice mail.
- Be aware of any local regulations governing cell phone use.
- Avoid other activities such as eating, drinking, or adjusting noncritical vehicle controls while driving.

5.4.2 Employers

- Avoid pressuring workers to routinely conduct business on a cell phone while driving.
- Monitor workers' crash experience related to the use of cell phones, in-vehicle Internet, and other technologies.
- Modify company policies on use of these technologies while driving if safety concerns demand it.

5.4.3 Manufacturers, Human Factors Professionals, and Policy Makers

- Provide consumers with educational materials about the dangers of driver distraction during use of cell phones and other technologies. Incorporate similar information into driver education programs and workplace driver training programs [NHTSA 1997].
- Consider the safety implications of combining cell phones with other information systems in vehicles. Equipment designers should consider developing systems that can temporarily divert incoming calls or potentially distracting visual displays when traffic conditions demand the driver's full attention [Burns and Lansdown 2000; NHTSA 1997; Parkes 1993].

5.5 CRASHES INVOLVING YOUNG DRIVERS

5.5.1 Employers

- Ensure that young workers who are assigned to drive on the job have a valid State driver's license.
- Require successful completion of a State-approved driver education course (where State laws provide for such courses) and require that the worker have a driving record free of any moving violations at the time of hire. For young workers who have not completed a driver education course, expedite their enrollment in driver training courses offered to all employees.
- Set policy according to State graduated driver licensing laws (particularly restrictions on night driving and the number of teen passengers) so that company operations do not place young workers in violation of these laws.
- Keep a driving log to ensure that young drivers do not exceed the maximum number of hours that may be driven. Even if the employer is not covered under FLSA, the provisions of this act nonetheless provide useful guidance for appropriate assignment of driving tasks to young workers.
- Assign driving-related tasks to young drivers in an incremental fashion, beginning with limited driving responsibilities and ending with unrestricted assignments. This recommendation extends to young drivers aged 18 or older who are still in the process of acquiring driving skills and experience—not just to those under age 18 who are covered by FLSA.

- Strictly enforce policies that require workers to wear safety belts in all vehicles (drivers and passengers). Since adolescents and young adults are less likely than older adults to wear safety belts, be particularly vigilant about enforcing safety belt use in this worker population.

5.5.2 Employers

- Provide supervised performance-based training, especially for young workers who are expected to operate specialized vehicles or equipment.

- Look for driver training programs that address hazard perception skills that may be lacking in young drivers.

5.6 CRASHES INVOLVING OLDER DRIVERS

5.6.1 Employers

- Offer periodic screening of vision and general physical health for all workers for whom driving is a primary job duty. Consider increasing the frequency of screening for workers aged 65 and older, but make sure that any such policy ensures fair treatment of all workers.

- Base decisions to restrict driving for older workers on assessments of actual driving ability—not solely on general medical screening or on an arbitrary age limit.

- If a worker's ability to drive on the job is impaired temporarily or permanently, make every effort to accommodate that worker to other job duties if he or she is able to perform them.

- Consider providing vehicles with features that may ease the driving task and decrease the risk of crashes and injuries among older workers. Such vehicle features include power steering and brakes, automatic transmission, clean and properly adjusted headlights, side air bags, and new technology such as crash avoidance systems and night vision enhancement systems. However, employers should be alert to the potentially negative effects of new technology, as older drivers may find it difficult and stressful to adjust to new aspects of vehicle operation [Holland and Rabbitt 1994; Maycock 1997].

- For older drivers, consider offering training sessions in which a skilled observer or driving instructor provides feedback on driving performance [Holland and Rabbitt 1994].

5.6.2 Transportation Planners and Traffic Engineers

The following changes in highway design, signage, and traffic control devices will help all drivers, and especially older drivers:

- Consider widening the pavement markings.
- Use large, well illuminated and maintained road signs and traffic control devices that convey simple, concise messages.
- Use directional turn arrows at busy intersections.
- Use positive barriers in crossovers and transition areas in highway construction zones.

[FHWA 2001; Maycock 1997; Sivak 1985]

5.6.3 Safety Professionals

- Develop driver training or refresher courses that are tailored to older workers and that provide information about age-related changes that may affect driving performance [Holland 1993]. These courses should address the driving situations that are most likely to pose difficulties for older drivers (e.g., driving at night, driving in intersections, and yielding the right of way). The courses should offer strategies for coping with these situations.

6 RESEARCH NEEDS

Although a considerable body of research addresses roadway safety issues in the general population, data are lacking in a number of areas relevant to work-related roadway safety. The following list outlines research that is needed to characterize occupational crashes, determine risk factors, and identify effective prevention strategies:

- Researchers should evaluate the effectiveness of workplace interventions to prevent roadway crashes.
- Research is needed to develop better measures of exposure to on-the-job driving. Fatality rates that are calculated on the basis of occupation or industry identify worker groups at highest risk but do not adjust for differences in hours or miles driven.
- Researchers should use existing programs such as the Crashworthiness Data System to investigate roadway crashes in which workers sustain nonfatal injuries, particularly those that involve a vehicle other than a large truck.
- Data systems specific to occupational fatalities and injuries should be evaluated and modified to conform with terminology used by the roadway safety community. CFOI currently does not contain adequate data on vehicle type, road type, environmental factors, driver-related factors, and manner of collision.
- Research is needed to assess the effects of safety management practices and work organization (e.g., scheduling and compensation practices, training and incentive programs, and vehicle selection and maintenance policies) on safety outcomes for occupational drivers.
- Research is needed to better describe risk factors for occupational crashes among workers who do not operate a vehicle as their primary job task. With the exception of large truck crashes, differences between work-related crashes and crashes in the general population are poorly understood.
- A broad-based effort is needed to arrive at improved methods for assessing and quantifying driver fatigue.

- Federal and State agencies should develop standardized national guidelines for assessing factors such as driver fatigue, driver distraction, and cell phone use in roadway crashes. Determination of these factors is largely subjective in the absence of guidelines for law enforcement officers and others who provide data on work-related and other crashes.

- Additional steps should be taken to improve quality and completeness of data on the involvement of cell phones and other electronic devices in roadway crashes:

  —Crash reports should be standardized nationwide to require that information be recorded about the involvement of cell phones, in-vehicle Internet, navigation systems, and other electronic equipment.

  —Studies that measure timing, duration, and content of cell phone calls during normal driving situations are needed to provide baseline data. Research projects that place event recorders and other instruments in cell phone users' vehicles will help to detect real-world changes in driving performance during cell phone use and to collect information about associated crashes and near misses [NHTSA 1997].

  —Federal agencies and the research community should work together to develop focused studies on the safety effects of cell phone use during on-the-job driving. These studies should assess differences between cell phone use in work and nonwork situations so that unique occupational risk factors can be identified.

- Research is needed to assess the role of commuting in work-related roadway crashes and the role of workplace factors in crashes that occur during commuting time. Under definitions used by existing data systems, a crash is not work related if it occurs during commuting to or from work. Workplace factors such as shiftwork, length of shift, and hours of driving while at work may influence the likelihood of crashes during commuting. Conversely, factors such as the length of the commute may be associated with the risk of a crash on the job.

7 CONCLUSIONS

Preventing work-related roadway crashes requires an approach that is both multidisciplinary and multifaceted. Different vehicle work environments call for different interventions, and no single intervention will suffice for a given work environment. Groups working primarily in occupational safety need to understand more fully the issues that influence worker safety on the roadway. Developing comprehensive prevention programs requires knowledge of areas as diverse as physiological responses to fatigue, highway and vehicle design principles, psychosocial factors that influence risk-taking in young drivers, and onboard vehicle monitoring technology. Roadway safety advocates might also benefit from a greater understanding and appreciation of the unique challenges to preventing work-related crashes. Increased collaboration between these two communities will optimize limited resources and improve the quality of programs for preventing all vehicle-related injuries and fatalities on the Nation's roadways.

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ONLINE RESOURCES

NOTE: The addresses below were correct as of July 2003. Since Internet addresses for Web sites change frequently, readers are cautioned that slight changes may have taken place since that time.

AAA Foundation for Traffic Safety
www.aaafoundation.org/home

Advocates for Highway and Auto Safety
www.saferoads.org

American Trucking Associations
www.trucking.org

Association for the Advancement of Automotive Medicine (AAAM)
www.carcrash.org

Citizens for Reliable and Safe Highways (CRASH)
www.trucksafety.org

Commercial Vehicle Safety Alliance
www.cvsa.org

Federal Highway Administration
www.fhwa.dot.gov

Federal Highway Administration
Turner-Fairbank Highway Research Center
www.tfhrc.gov

Federal Motor Carrier Safety Administration
www.fmcsa.dot.gov

Insurance Institute for Highway Safety
www.hwysafety.org

National Highway Traffic Safety Administration
http://www.nhtsa.dot.gov

National Institute for Occupational Safety and Health
www.cdc.gov/niosh

National Safety Council Highway Traffic Safety Division
www.nsc.org/mem/htsd.htm

National Transportation Safety Board
www.ntsb.gov

Network of Employers for Traffic Safety
www.netsnational.org

Occupational Safety and Health Administration
www.osha.gov

Parents Against Tired Truckers
www.patt.org

Transportation Research Board
www.national-academies.org/trb

University of Michigan Transportation Research Institute (UMTRI)
www.umtri.umich.edu

U.S. Department of Transportation
www.dot.gov

APPENDIX A
SIC 1987 Industry Divisions

Industry division (SIC major group)	Description
Agriculture, Forestry, and Fishing (01–09)	Businesses engaged primarily in agricultural production, forestry, commercial fishing, hunting and trapping, and related services including landscape and horticultural services, veterinary services, and farm labor and management services.
Mining (10–14)	Businesses engaged in the extraction of minerals occurring naturally: solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. Includes quarrying, well operations, and firms that explore and develop mineral properties.
Construction (15–17)	Businesses engaged in new construction, additions, alterations, reconstruction, installations, and repairs. Covers building construction by general contractors or operative builders, heavy construction other than building by general contractors or special trade contractors, and construction activity by other special trades contractors.
Manufacturing (20–39)	Businesses engaged in the mechanical or chemical transformation of materials or substances into new products. Usually described as plants, factories, or mills that use power-driven machines and material-handling equipment.
Transportation, Communications, and Public Utilities (40–49)	Businesses providing the general public or other businesses with passenger and freight transportation, communications services, or electricity, gas, steam, water, or sanitary services. Includes the U.S. Postal Service.
Wholesale Trade (50–51)	Businesses primarily engaged in selling merchandise to retailers; to industrial, commercial, farm, or construction contractors; or to other wholesalers. Also includes businesses acting as agents in buying merchandise for or selling merchandise to such persons or companies.
Retail Trade (52–59)	Businesses primarily engaged in selling merchandise for personal or household consumption and rendering services incidental to the sale of goods. Retail businesses are classified according to the principal commodities sold (e.g., groceries, clothing).
Finance, Insurance, and Real Estate (60–67)	Covers commercial banking, savings institutions, and credit unions; securities and commodities exchanges and brokerages; insurance carriers, agents and brokers; management of commercial and residential rental properties; real estate agents; and land developers.
Services (70–89)	Covers hotels and other lodging places; businesses providing personal, business, repair, and amusement services; health, legal, engineering, and other professional services; educational institutions; and membership organizations.
Public Administration (91–97)	Includes the executive, legislative, judicial, administrative, and regulatory functions of Federal, State, local, and international governments. Government-owned and operated establishments (e.g., highway construction work done by a State department of transportation) are classified in major groups 01–89.

Source: Adapted from OMB [1987]. SIC manual 1987.

APPENDIX B

BOC 1990 Occupation Groups

Occupation group (BOC codes)	Description
Executive, Administrative, and Managerial (003–037)	Includes government officials, accountants, funeral directors, and managers in fields such as education, food service, real estate, medicine, finance, and marketing.
Professional Specialty (043–199)	Includes engineers, architects, health care practitioners, teachers, lawyers, writers, artists, entertainers, athletes, and natural, social, mathematical, and computer scientists.
Technicians and Related Support (203–235)	Includes technicians in health, engineering, law, and laboratory sciences; airplane pilots and navigators; air traffic controllers; and computer programmers.
Sales (243–285)	Includes sales workers in real estate, insurance, advertising, mining, manufacturing, wholesale, and retail; cashiers; vendors; and supervisors of sales workers.
Clerical (303–389)	Includes secretaries, clerks, bookkeepers, mail carriers, bank tellers, teachers' aides, dispatchers, ticket agents, and supervisors of workers in these occupations.
Services (403–469)	Includes law enforcement and corrections officers, firefighters, security guards, cooks and food servers, health aides, janitors and cleaners, hairdressers, attendants at recreation facilities, and child care workers.
Farming, Forestry, and Fishing (473–499)	Includes farm operators, hired farm laborers, nursery workers, groundskeepers and gardeners, agricultural inspectors, animal caretakers, foresters, loggers, fishers, hunters, and trappers.
Precision Production, Craft, and Repair (503–699)	Includes mechanics; repairers; miners; machinists; tailors; butchers; bakers; well drillers; and specialized construction trades workers such as carpenters, plumbers, bricklayers, roofers, electricians, painters, and drywall installers.
Operatives (703–799)	Includes a wide range of machine operators, assemblers, and inspectors: welders; graders and sorters; and operators of machines that work on metal, wood, plastic, textiles, and printed materials.
Transportation and Material Moving (803–859)	Includes truck, bus, and taxi drivers; locomotive operators; sailors and deck hands; and operators of heavy equipment such as cranes, excavators, and forklifts.
Laborers (864–889)	Includes general and construction laborers, stock handlers and baggers, garbage collectors, stevedores, and workers at garages and gasoline service stations.

Source: Adapted from BOC [1992]. Alphabetical index of industries and occupations.

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