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New Research and Findings from the NIOSH Division of Safety Research

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Introduction

The National Institute for Occupational Safety and Health (NIOSH) and the American Society of Safety Engineers (ASSE) are longstanding partners, with the most recent formal partnership agreement signed in May 2012 (NIOSH/ASSE 2012). The formal partnership agreement documents the commitment by NIOSH and ASSE to work together to advance worker safety, promote best practices, support the translation of research into practice, and encourage the use of evidence-based prevention strategies.

This paper is in the spirit of the NIOSH/ASSE partnership. It provides an overview of NIOSH and the Division of Safety Research, the focal point within NIOSH for traumatic injury research, and provides information on Division research and products that can be used by ASSE members to improve worker safety. The paper includes highlights of recent and in-progress research for three leading causes of worker deaths and injuries: violence, falls from heights, and motor vehicle crashes.

NIOSH and Division of Safety Research Overview

NIOSH

NIOSH is the federal agency responsible for occupational safety and health research. Our mission is to generate new knowledge in the field of occupational safety and health and to transfer that knowledge into practice for the betterment of workers. NIOSH does not have regulatory authority to mandate safer work conditions and practices. We rely on others to act upon our findings. We provide science-based recommendations to regulatory agencies such as the Occupational Safety and Health Administration (OSHA). Staff also participates on voluntary consensus standards committees, including many ASSE-led American National Standards Institute (ANSI) committees. We value and nurture partnerships with a wide variety of stakeholders to both inform our research and to aid in the translation of research to practice.

Division of Safety Research

The Division of Safety Research is one of several NIOSH research divisions and laboratories. We conduct research on traumatic occupational injuries, or injuries that immediately result from exposure to physical hazards and energy sources (such as fractures, crushing injuries, amputations, head injuries, burns, and cuts).

The Division's research responsibilities are formidable. Traumatic occupational injuries exert a tremendous toll on the nation's workers, their families, employers, and society as a whole. During 2010, 4,690 workers died from injuries sustained at work (Bureau of Labor Statistics (BLS) 2013a). That same year, workers in private industry sustained approximately 2.9 million injuries (BLS 2013b). More than 530,000 of those injuries resulted in workers missing six or more days of work, referred to as serious injuries throughout this paper (BLS 2013c). Traumatic occupational injuries contribute to pain and suffering of workers, economic hardships on families, employer and insurer costs for workers' compensation, and societal costs and impacts. Workers' compensation costs for serious injuries alone were estimated by the Liberty Mutual Research Institute for Safety at $51.1 billion dollars in 2010 (Liberty Mutual 2012). A recent economic analysis by J. Paul Leigh of the University of California at Davis estimated that occupational injuries cost the nation a staggering $192 billion dollars annually, factoring in societal costs such as health care costs not paid for by workers' compensation systems and lost productivity (Leigh, 728).

Division Research

The Division works to prevent traumatic occupational injuries by conducting high quality research that is data-driven and focuses on the most compelling injury risks. We are committed to developing practical solutions that can be used by employers and workers. We involve partners throughout the entire research continuum, from research conceptualization to dissemination of findings, to ensure our research is relevant to stakeholders, and to position our research findings for action by others. ASSE representatives and members are partners on many of our research projects.

The Division follows the public health model, melding in safety and engineering sciences. The public health model involves four steps: (a) the collection of data, termed surveillance in public health parlance, to understand both the size and characteristics of health problems and to monitor trends, (b) research to identify modifiable factors that can be addressed to interrupt the sequence of events leading to a health or injury problem, (c) the development and testing of interventions, and (d) disseminating and encouraging the use of effective interventions to improve the public's health. The Division incorporates safety and engineering sciences into the public health approach. We use epidemiologic methods to define injury problems and to focus intervention efforts, and safety and engineering sciences to address human factors issues and to develop and test control technology.

The Division follows a staged approach in disseminating research findings and products. Scientific peer review is conducted to ensure science quality and integrity, and research is usually first published in peer-reviewed scientific publications or NIOSH documents which is important for establishing scientific credibility. We then repackage the information for employers, workers, and trade and labor organizations.

Division research is focused on or applicable to multiple industry sectors. Some research, including surveillance, is conducted across all industry sectors. Other research is focused on specific industry sectors, including: agriculture, construction, education, healthcare, manufacturing, public safety, retail trades, services, and transportation.

Strategic Goals

The Division's work is guided by strategic goals driven by data on the most common causes of occupational deaths and injuries, and disparities in the incidence and risk of occupational injuries across worker groups (NIOSH 2009). Goals address reduction of occupational (a) violence, (b) fall injuries, (c) motor vehicle-related injuries, (d) injuries associated with machines and industrial vehicles, and (e) injuries among high risk and vulnerable worker groups. There is also a goal to increase the use of surveillance data to guide traumatic occupational injury research and prevention. This paper highlights findings from three strategic goals: workplace violence, fall injuries, and motor vehicle injuries.

Surveillance

Because surveillance is so foundational to the Division's work, some information on our surveillance program is warranted. We collect and use two types of surveillance data: population-based and case-based.

Population-based surveillance involves the collection and analysis of data that represents or can be generalized to a population of workers, such as workers in the U.S., in states, and in industry sectors. This includes Division analyses of data from BLS, such as much of the data included in this paper. We also collect data to complement and fill-in some of the gaps in the data collected by BLS, to contribute to a more complete picture and understanding of occupational injuries. This includes data on injuries treated in hospital emergency departments and data on agricultural injuries (NIOSH 2013a). We are also engaged in research to better understand how existing data systems may be impacted by underreporting of injuries.

While population-based surveillance is useful for assessing the burden and characteristics of occupational injuries, such data frequently lacks details needed to understand the multitude of factors that contribute to occupational injuries. The Division uses case-based surveillance to collect details that are not feasible to collect on a population basis, but that are critical for understanding the root causes of occupational injuries and identifying promising interventions. Examples of data collected in case-based surveillance that often are not feasible to collect on a population-basis include: information on employer safety programs, deficiencies in these programs, or a lack thereof; information on safety training, or the absence of training; detailed information on work processes and equipment, including identification of design deficiencies and equipment malfunctions; and worker use of personal protective equipment, and any deficiencies in how the equipment was used.

The Division has a long-standing case-based surveillance system called the Fatality Assessment and Control Evaluation (FACE) Program. The FACE program conducts field-based investigations of selected types of fatalities, adjusted over time in response to emerging issues. Investigations are summarized in narrative reports that detail the circumstances of the fatality and recommend measures to prevent future deaths under similar circumstances (NIOSH 2013b). The FACE reports tell the stories behind the statistics and provide insights into root causes that cannot be teased out from population-based surveillance systems. The FACE reports are popular with

safety professionals who note that they are useful for engaging workers and conveying the real versus theoretical injury risks in the work environment. The NIOSH website includes more than 2,400 FACE reports written by Division staff or state partners, http://www.cdc.gov/niosh/face/. The reports are organized on the website by: location; industry; cause, such as falls and machines; and worker demographics. The webpage also includes a search engine to help identify cases of interest.

Workplace Violence Highlights

Surveillance and Costs of Serious Injuries

Violence is a leading cause of work-related deaths and injuries, with substantial monetary and psychological costs to workers, their families, employers and communities. Violence is the second leading cause of work-related injury deaths, exceeded only by transportation-related fatalities (BLS 2013a). In 2010, 518 workers were murdered while working. Most were shot (78%), followed by stabbings (7%), and physical assaults, such as hitting, kicking, and beating (5%). Data compiled over the 14-year period from 1997 to 2010 demonstrate that 75% of the murders were committed by robbers or other assailants, 10% by co-workers or former co-workers, 7% by customers or clients, and 7% by relatives and other personal acquaintances (BLS 2013d). Specific industries with large numbers of work-related homicides during this period include: restaurants (367), police protection (360), convenience stores (271), and taxicabs (258).

In 2010, U.S. workers in private industry sustained 16,900 injuries requiring at least a day away from work as a result of assaults by persons (BLS 2013c). Shootings and stabbings were infrequent, with most injuries associated with kicking, hitting, and beating. The industry sector with the most nonfatal assaults was education and health services, with 11,970 assaults (BLS 2013e). More than half of the 16,900 (8,790) assaults in private industry in 2010 were serious, resulting in more than 6 days away from work (BLS 2013c). Liberty Mutual estimated workers' compensation costs for serious work-related assaults at $640 million in 2010 (Liberty Mutual 2012). Most of the injuries were caused by personal assaults, but the injury data also include animal attacks and suicide attempts. The statistics on nonfatal assaults should be considered conservative since they do not include government workers, and in some professions such as emergency services, and healthcare, violence is likely underreported since workers consider it "part of the job."

Research

Workplace violence is a complex problem with different high risk groups for disparate types of violence that include: crime-associated violence such as assaults against police officers and robbery of restaurant workers, convenience store staff, and taxicab drivers; violence (intentional and unintentional) expressed by healthcare patients and students; violence between employees; and, domestic violence that encroaches into the workplace.

The Division has conducted research to better quantify and characterize workplace violence in different industries, and has recommended and is evaluating a variety of prevention strategies. Past research has influenced OSHA nonregulatory guidelines (and subsequent regulations and guidelines in some states and municipalities) for preventing violence in healthcare and social service settings, late-night retail, and the taxicab industry (OSHA 2004, 2009, 2010). The NIOSH website includes several publications on workplace violence, including a document

specific to preventing violence in hospitals and a training and educational DVD that can be used to raise awareness of workplace violence and prevention measures, http://www.cdc.gov/niosh/topics/violence/pubs.html. Following are examples of recent research and products that are forthcoming.

Special Journal Issue Focused on Violence
In 2012, a special issue of the international scientific peer-reviewed journal, *Work: A Journal of Prevention, Assessment & Rehabilitation,* focused on workplace violence (Menéndez). This special issue was guest edited by a Division researcher, Dr. Cammie Chaumont Menéndez. The journal includes 18 articles that provide overviews of occupational violence, information on trends, and articles addressing specific work environments, such as healthcare, education and law enforcement.

Interpersonal Violence against Women at Work
In 2012, a Division researcher, Dr. Hope Tiesman, along with colleagues, published a scientific article that examined the circumstances of homicides of women at work (Tiesman et. al. 2012). While the most common circumstance was criminal intent, such as robbery, a startling one-third of the homicides were committed by personal relations, with the majority by intimate partners. These findings illustrate the importance of workplace violence prevention programs addressing interpersonal violence as well as violence by criminals, patients and clients.

Violence against School Personnel
In February, 2013, Dr. Tiesman, along with colleagues, published the first article from a recently completed study of violence against school personnel in Pennsylvania (Tiesman et al. 2013). This study was conducted in partnership with national and state educational associations, school districts, and teachers' unions. This study found that in the 2009/2010 school year, about 8% of workers were physically assaulted and 29% experienced non-physical violence, such as verbal assaults, threats, and sexual harassment. The majority of physical assaults occurred during regular school hours, did not involve weapons, and were perpetrated by students. Special education teachers experienced more violence than general education teachers and other education employees.

Interventions to Prevent Violence against Taxicab Drivers
Division researchers, led by Dr. Menéndez, are completing a large study that is evaluating the impact of city or employer policies that mandate one of two types of taxicab safety equipment (security cameras or bullet-proof partitions) on the incidence of taxicab driver homicides. This research is being conducted in partnership with police departments, municipal taxicab regulators, the International Association of Transportation Regulators, and the Taxicab, Limousine & Paratransit Association. Peer-reviewed papers reporting results from this study are expected in 2013. A Division researcher, Dr. Shengke Zeng, is conducting engineering assessments to recommend performance specifications for security cameras used in taxicabs, with these recommendations also anticipated in 2013.

Interventions to Prevent Violence against Convenience Store Workers
Division researchers, also led by Dr. Menéndez, are nearing completion of a study that is evaluating the efficacy of municipal regulations in two large Texas cities in increasing the use of evidence-based violence prevention measures. This research is being conducted in partnership with city governments, police departments, and a small-business association. Previous studies by

Division researchers and others have proven that there are several measures that convenience stores and other small retail businesses can take to improve worker safety (such as keeping the line of sight from the street to the register clear, implementing a cash management system that minimizes cash on hand, and installing security cameras and drop safes in conjunction with policies and worker training on non-resistance during a robbery). However, these prevention measures are not widely adopted, especially among small retail businesses. This study will provide insights into the efficacy of municipal regulations in increasing violence prevention measures in small retail businesses. Publication of findings is anticipated in peer-reviewed publications in 2013.

On-line Training Course on Preventing Violence against Healthcare Workers
Surveillance data demonstrate that workplace violence in healthcare is common, primarily associated with violence from patients or their family members. Division researchers, Dr. Dan Hartley and CDR Marilyn Ridenour have several ongoing research projects evaluating regulatory and organizational interventions to prevent violence against healthcare workers.

One of the things the Division has learned from our history of conducting research on violence in healthcare settings is that healthcare personnel often consider violence a "part of the job" (Hartley et al.). In an effort to raise awareness of workplace violence amongst healthcare workers and different strategies to protect healthcare workers, Dr. Hartley and CDR Ridenour have partnered with academic researchers, professional organizations, union representatives, and a professional video training company to develop an on-line training course for nurses. This will be a self-paced course that nurses can complete at home or work, and for which they will earn free continuing education units. The course includes video vignettes of real-life stories and video enactments. The course will provide information on: (a) workplace violence in healthcare, (b) the importance of reporting workplace violence so that employers can recognize and address the problem, (c) steps personnel can take to protect themselves, and (d) steps they can take to engage their employers in comprehensive violence prevention programs. We anticipate the free on-line course being available by spring 2013 on the NIOSH website, http://www.cdc.gov/niosh/.

Fall-Prevention Highlights

Surveillance and Costs of Serious Injuries
Workers falling to a lower level is a leading cause of fatalities and contributes to numerous serious injuries. Fall-related fatalities is the fourth most frequent event following transportation; assaults and violence; and contact with objects and equipment (*i.e.*, struck-by and caught-between) (BLS 2013a). A total of 646 fatalities (13.8% of all 2010 fatalities) were caused by all types of falls in the U.S in 2010. Falling to a lower level accounted for 522 deaths (81%), while falls on the same level contributed to 100 deaths (15%). Jumping to a lower level and falls that were not defined or did not fit into a specific category accounted for the remaining 24 fatal injuries (4%). For all U.S. industries, falls from ladders caused the most fatalities, followed by workers falling from roofs, non-moving vehicles, and then scaffolding.

In 2010, a total of 128,210 fall-related serious injuries occurred, and were the second-most frequent serious event following bodily reaction and exertion (BLS 2013c). In contrast to the high frequency of fatalities caused by falling to a lower level (*i.e.*, 81%), a total of 40,080 (31%) workers sustained a serious injury that was caused by falling to a lower level. Thus, falls to a lower level make up a far higher proportion of the fall fatality burden as opposed to the serious

injury burden. Of the 40,080 serious injuries, 26% (10,380) involved ladders, 24% (9,780) involved stairs or steps, and 18% (7,150) involved non-moving vehicles. The fourth leading fall origin is floors (2,300 incidents or 6%) with falls through holes and from unguarded edges. Fifth is falls from roofs (again through holes and especially from unguarded edges) amounting to 1,400 (4%) serious injuries. About 60% of the roof falls were classified as fall from the roof edge.

Even though falls from roofs accounted for only the fifth highest number of serious fall injuries, the number of days away from work for a fall from a roof edge is staggering. In 2010, 800 of the 1,400 roof-edge falls were classified as serious (BLS 2013c). The median number of days away from work after falling from a roof edge is 142, more than 6 months. As a comparison, the median number of days away from work for all types of falls to a lower level is 16.

Liberty Mutual reports that "falls to lower level" are the fourth most costly serious occupational injury, with workers' compensation costs totaling $5.12 billion in 2010 (Liberty Mutual 2012). Dividing this total dollar value by the 40,080 serious fall-to-lower-level injuries suggests an average of $127,740 in direct compensation costs per seriously injured worker.

National Fall-Prevention Campaign

On April 26, 2012, a two-year national campaign to *Prevent Falls in Construction* was launched to "encourage everyone in the construction industry to work safely and use the right equipment to reduce falls." (NIOSH 2013e) The focus of this campaign is to reduce the number and severity of falls from ladders, scaffolds, and roofs. The motto of the campaign is "Safety Pays, Falls Cost". The campaign is co-sponsored by OSHA, NIOSH, and CPWR—The Center for Construction Research and Training. The idea for the campaign originated from discussions that occurred among multiple stakeholders through the NIOSH NORA (National Occupational Research Agenda) Construction Sector program. Those stakeholders included internal NIOSH researchers and external organizations, such as universities, large and small businesses, worker organizations, professional societies, and other government agencies. ASSE is partnering in publicizing the campaign. The campaign is using a variety of strategies to reach the construction industry through a three-part message – ***Plan, Provide, and Train***. Plan ahead to get the job done safely; Provide the right equipment for workers; and Train everyone to use the equipment safely. Materials and resources are available on the campaign websites, www.stopconstructionfalls.com, hosted by CPWR, or http://www.osha.gov/stopfalls/, or http://www.cdc.gov/niosh/construction/stopfalls.html.

During the first nine months of the national campaign, the three sponsoring organizations indicated that the effort has been a "great success." The co-sponsors also reported that more than "300,000 people have been touched by the campaign, and [that] the research supporting the campaign received the prestigious 2012 Thoth award from the Public Relations Society of America." (Campaign letter update, Jan 31, 2013) A brief evaluation of the first four months of the campaign indicated that information was not reaching small construction contractors, who comprise the primary target audience. Efforts to reach them will be a key focus of the second year of the campaign. NIOSH is pleased that the dozens of participants remain committed to this endeavor and anticipate continued success in the future. Designs for a robust evaluation of the second year are underway, but have not yet been finalized.

The campaign is focused on preventing workers from being injured when working with ladders and scaffolds, and when working on roofs. Many research projects conducted by the

Division have dealt with these workplace situations and Division research has contributed to the campaign effort.

Research

The statistics presented previously indicate that for all U.S. industries, ladders are the primary cause of fall-related fatalities and serious injuries. Workers falling from roofs is the primary cause of fatalities in the construction industry. On-going research studies are focused on ladder safety and roof safety primarily in the construction industry, as well as testing and evaluating a relatively newer type of equipment – a mast climbing work platform.

Division research on fall prevention activities has been conducted with numerous partners, including: CPWR, the American Ladder Institute, a manufacturer of a scissor lift, a manufacturer of a mast climbing work platform, the West Virginia University Safety and Health Extension Office, West Virginia Home Builders Association, and north-central West Virginia residential contractors. Division personnel also participate on relevant consensus standards committees to encourage the consideration of Division research findings as existing standards are revised and new ones are developed. These include the ASSE-led ANSI Z-359 Committee on Fall Protection Guidelines; the ASSE-led ANSI A10 Committee on Safety and Health Issues in Construction and Demolition Operations, and the Ladder Institute-led ANSI A-14 Committee on Ladder Safety. The ANSI-ASSE A10 Committee has numerous Subcommittees that relate to Division research activities. These include the ANSI A10.18 Subcommittee on Temporary Roof and Floor Holes, Wall Openings, Stairways, and Other Unprotected Edges; ANSI A10.24 Subcommittee on Safety Requirements for Low-Sloped Roofs; and ANSI A10.29 Subcommittee on Safety Practices for Use of Aerial Platforms in Construction.

Ladders

When setting an extension ladder, the traditional approach has been for the worker to grasp the rung in front of them with outstretched arms, which is shown in Figure 1 on the left. Division researchers, led by Dr. Peter Simeonov, have demonstrated a better method – grasping the side rails of the ladder instead of a step (Simeonov et al. 2012a). This variation (Figure 1 on the right) results in a more natural placement of the outstretched hands, and a ladder angle that is safer for climbing.

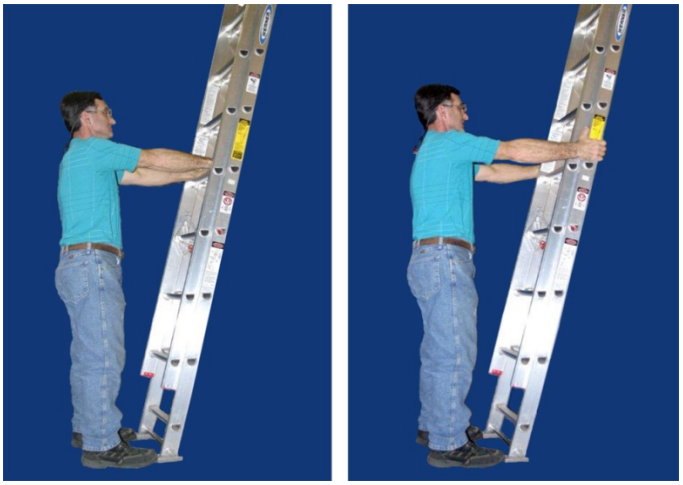

Figure 1. Left – worker using the old method of grasping the rung. Right – worker using the new method of grasping the side rails, which results in a safer ladder angle for climbing.

Regarding ladder placement, a Division research study, also led by Dr. Simeonov, has developed and tested an engineering solution (the multi-modal indicator), which has been patented (U.S. Patent No 8,167,087). This device helps ladder users position extension ladders at the optimal angle quickly and easily, with reduced risk for slide-out and fall incidents. The indicator provides direct feedback to the user with visual, auditory, and vibration signals when the correct angle has been reached (Simeonov et al. 2012b). The research team is working with an external contractor to make the concept of the indicator device available to the general public through a smart phone application. Figure 2 provides smart phone screen shots of the NIOSH multimodal indicator.

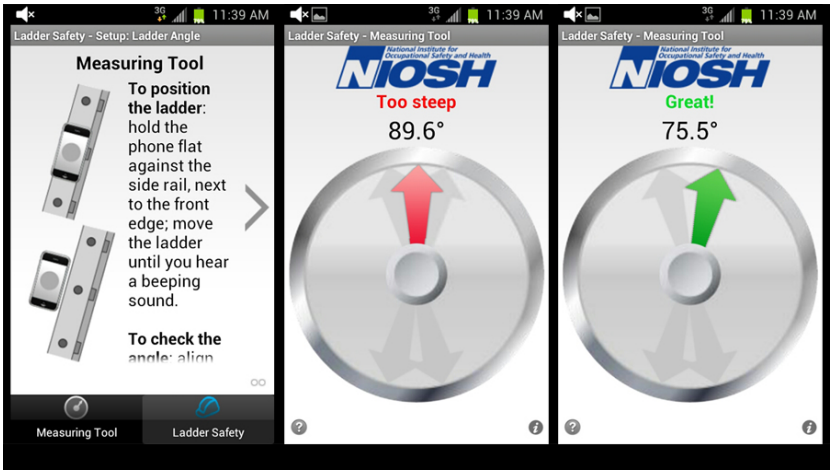

Figure 2. NIOSH smart phone application screen shots. Left view shows the indicator being used to set the correct angle. Middle view shows too steep of an angle. Right view shows the correct angle using the indicator.

Another innovation that is being evaluated is electro-adhesion technology. This breakthrough technology was developed by a California company. Electro-adhesion uses electrostatic forces between a surface, such as a wall, and the innovative electro-adhesive pad that is comprised of conductive electrodes. A small battery pack supplies power to each adhesive pad. Division researchers, led by Dr. Simeonov, are evaluating the use of this technology to help stabilize extension ladder placement at either one or both ends of the ladder. Modifications were made to a ladder to permit the evaluation of this technology. A patent application has been submitted for using electro-adhesion technology with an extension ladder.

Roofs

Fall-related incidents are the primary cause of fatalities in the U.S. construction industry. A Division study, led by one of this paper's authors, Dr. Thomas Bobick, evaluated the strength of job-built guardrail structures made of two-by-four lumber and 16-penny nails, which are standard for construction carpenters. Full-time carpenters served as test subjects. Test results and feedback

from the workers helped to develop a patented (U.S. Patent No. 7,509,702) multifunctional guardrail system that can be used on roofs, as well as on stairs and floors to protect workers from falling through holes or from unguarded edges (Bobick and McKenzie). The guardrail system has been in use by one northern West Virginia construction contractor for more than 18 months. This contractor has used the system on at least six different job sites with great success. The guardrail system is available for commercial development through a licensing agreement with CDC-NIOSH. Figure 3 provides two views of the system in use on different residential construction sites.

Figure 3. Left view shows the flat and vertical components of the guardrail system being used to construct a temporary handrail. Right view shows two separate guardrail systems, constructed of the roofing components, installed on a large 45° sloped roof.

Aerial Lift

A method of reducing the number of fall-related incidents with ladders is to replace the use of ladders with personnel lifts. This is easier in a manufacturing setting with smooth floors for the vehicles to travel over, but rugged-terrain boom lifts have been used successfully in the construction industry. The use of this type of equipment has its own set of concerns associated with the stability of the equipment when the boom or the scissors lift is extended. A Division research study led by Dr. Christopher Pan evaluated the stability of workers when the equipment is moving, as well as when it is stationary with the boom extended and the worker is conducting job tasks that involve exertions (Pan et al.). Laboratory simulations determined the stability of the equipment during the job tasks. In addition, a computer model simulated movement with the boom extended. Finally, laboratory research demonstrated that aerial lifts could withstand substantial external forces, demonstrating promise for the use of fall protection systems with the lifts (Harris et al.) Figure 4 shows the scissor lift extended to a total of 19 ft. 9 inches in the Division High Bay Lab during the stability testing. These tests did not include human subject testing, but were restricted to dropping a rigid weight, followed by dropping a test manikin.

Figure 4. View of the scissor lift extended (almost 20 ft.) in the Division's High Bay Lab during stability testing.

Mast Climbing Work Platform

The work being conducted with the mast climbing work platform is a direct follow-on to the aerial lift project. Many of the Division's research objectives build on what has been investigated previously. A 40-ft mast (vertical height) and climbing platform is on loan to the Division to conduct full-scale tests of stability and platform dynamics when the platform is fully loaded (Figure 5). Currently, OSHA regulations have not been developed related to mast climbing equipment. The Construction Directorate of OSHA and the Advisory Committee [to OSHA] for Construction Safety and Health (ACCSH) are both interested in the Division's research efforts. Despite the increased initial costs over using traditional scaffolding, this newer equipment is becoming more popular because it: (a) is able to safely reach higher work elevations, (b) is more stable at elevations, (c) contributes to increased productivity, and (d) may result in lower operating costs over the life of larger construction jobs.

Figure 5. View of the mast climber equipment to be used in future Division stability tests.

Motor Vehicle Safety Highlights

Surveillance and Costs of Serious Injuries

The risk of work-related motor vehicle crashes (MVCs) affects millions of U.S. workers. Fatality data show that across all industries, MVCs are consistently the leading cause of work-related fatalities, and the first or second leading cause in every major industry sector. Of 43,025 work-related fatalities reported by BLS between 2003 and 2010, 15,396 (36%) were associated with motor vehicles.[1] The toll for 2003-2010 included 10,202 deaths in single- or multiple-vehicle crashes on public roadways, 2,487 deaths in crashes that occurred off the highway or on industrial premises, and 2,707 pedestrian worker deaths as a result of being struck by a motor vehicle.

Although MVCs make up a small proportion of nonfatal lost-workday injuries reported by BLS (35,490 of 933,200 in 2010), a high percentage of these tend to be serious injuries. In 2010, BLS reported 24,060 lost-workday injuries in the private sector as a result of an MVC on a public roadway, 13,940 (58%) of which were serious injuries with 6 or more lost workdays. In the same year, there was an additional 4,920 lost-workday injuries from MVCs not on public roadways, 3,050 (62%) of which were serious injuries, and 6,510 lost-workday injuries resulting from a

[1] Source: Bureau of Labor Statistics online query system at http://data.bls.gov/cgi-bin/dsrv?fi

pedestrian worker being struck by a motor vehicle, 4,380 (67%) of which were serious injuries (BLS 2013c).

An analysis of the costs of MVCs to U.S. employers using data from 1998-2000 found that on average, each fatality cost a business over $500,000 in direct and liability costs, and each non-fatal injury cost nearly $74,000 (National Highway Traffic Safety Administration 2003). More recently, for MVC-related injuries requiring more than 6 days away from work, workers' compensation costs were estimated to be nearly $2 billion (Liberty Mutual 2012, 2).

NIOSH Center for Motor Vehicle Safety

Over the past 15 years, NIOSH has devoted considerable effort to building capacity for research and prevention activities related to occupational road safety, (www.cdc.gov/niosh/topics/motorvehicle). In 2010, NIOSH Director Dr. John Howard created the NIOSH Center for Motor Vehicle Safety as a "virtual center" charged with coordinating NIOSH's response to this pressing worker safety issue, and asked the Division to host the Center. Dr. Stephanie Pratt, a co-author of this paper, serves as the Coordinator for the Center. The Center serves as a focal point for information for NIOSH programs and products, assists researchers in developing research ideas, and interacts with external partners. Through the Center, NIOSH seeks to effect change through a variety of mechanisms: communication of research results through the peer-reviewed literature and industry channels, safety information targeted to employers and workers, changes in government regulations, and development of voluntary consensus standards.

Research

Like other Division programs, the NIOSH Center for Motor Vehicle Safety follows the "public health model," which begins by identifying causes of injury and risk factors, and progresses to development and evaluation of interventions and communication of findings to stakeholder groups. Risk factors have been identified through analysis and interpretation of injury and fatality data for specific worker groups such as law enforcement officers (Tiesman et al. 2010) , oil and gas extraction workers (Retzer, Hill, and Pratt), and emergency medical services workers (CDC 2003). Division authors have also compared risk of occupational crashes across industries and occupations (CDC 2004, 2011; Chen, Pratt). Injury prevention resources available from NIOSH include general guidance for employers on managing road risk (NIOSH 2004; Pratt), guidance on older drivers in the workplace (NIOSH 2005), and a video to promote seat-belt use among workers in the oil and gas extraction industry (NIOSH 2008). Other products that are anticipated during 2013 include educational materials on young drivers in the workplace targeted to both parents and employers, a technical document on motor vehicle injury prevention among law enforcement officers, and a research article on motor vehicle safety for older workers.

Findings from analysis of injury and fatality data have led to focused laboratory and field research to advance prevention of MVCs and resulting injuries in high-risk populations. Research has addressed two populations: truck drivers, who account for about 40% of occupational MVC fatalities; and high-risk worker groups among the remaining 60% of fatalities. Within this 60%, occupations such as fire fighters and law enforcement merit attention because of their unique operating environments. It is, however, also important to recognize that millions of workers across all occupations and industries operate motor vehicles in the course of their work, and that there is a demand for research-based information to help all kinds of organizations manage road risk for workers.

Truck Drivers

In response to compelling injury and fatality data, NIOSH and the Division have devoted considerable attention to truck driver safety. With support from the Federal Motor Carrier Safety Administration (FMCSA), NIOSH conducted a national survey of long-haul truck drivers, collecting information on driver and company attributes, health and lifestyle factors, fatigue, and occupational injuries. Publications from the survey are now in preparation. NIOSH researchers have also developed a series of satellite radio spots to help truck drivers manage fatigue more effectively.

A second line of trucking safety research has taken advantage of Division expertise in anthropometry (the scientific measurement of body dimensions) to help design safer and more ergonomically efficient work environments. Division researchers, led by Dr. Jinhua Guan, conducted a nationally representative field survey of truck drivers using advanced digital body scanning and more traditional manual measurements. The study found that male truck drivers were, on average, 13.5 kg (29.8 lbs) heavier than their counterparts in the general population, and female truck drivers were, on average 15.4 kg (34 lbs) heavier (Guan et al., 855). Results from the anthropometric study have been transferred to vehicle manufacturers, who will use them to design the next generation of truck cabs to better accommodate today's population of truck drivers. The safety implications of these design changes are many: improved visibility for drivers, better vehicle control, improved seat-belt design, and reduced risk of chronic conditions such as low back pain.

Emergency Responders

In partnership with other Federal agencies and private-sector partners, the Division is engaged in a comprehensive program of research and prevention activities for preventing MVCs among emergency responders, including fire fighters and emergency medical services (EMS) workers. These activities encompass a case-based surveillance program that investigates fire fighter line-of-duty fatalities due to MVCs, which leads to comprehensive case reports that are disseminated throughout the fire service nationwide, www.cdc.gov/niosh/fire, and educational materials on topics such as tanker-truck rollovers, safety at railroad crossings, and fire fighters working along roadways, http://www.cdc.gov/niosh/fire/othpubs.html.

In response to stakeholder interest and research needs, Division research in ambulance safety, led by Mr. James Green, has centered on human factors and engineering approaches. There are no comprehensive safety standards that specify requirements for safety and crashworthiness of ambulances. Of special concern to the Division is the safety of workers in the ambulance patient compartment, where work tasks are not compatible with the use of occupant restraints and where equipment and interior layout put workers at high risk of injury in the event of a crash. Partners in this research include the Department of Homeland Security, the National Highway Traffic Safety Administration, the National Institute of Standards and Technology, and the National Truck Equipment Association, Ambulance Manufacturers Division. Sled and crash tests of ambulances conducted by the Division and partners show that retrofitting patient compartments with redesigned occupant restraints will allow EMS workers the level of mobility needed to care for patients and at the same time afford greater protection from injury than standard lap belts (Green et al.). Division work in this area has led to development of new voluntary standards for crash testing and design of ambulances which will have industry-wide impact on manufacturing practices. Most recently, the National Fire Protection Association

(NFPA) promulgated the first voluntary consensus standard on the manufacture of ambulances (NFPA 2013).

Consensus Standards Contributions

In addition to its specialized work on ambulance standards, NIOSH has contributed to national and international fleet safety management standards. ASSE coordinated the development of the ANSI/ASSE Z15.1 standard, *Safe Practices for Motor Vehicle Operations*, a national consensus standard targeted at organizations operating small- and medium-sized vehicles not covered by FMCSA regulations for large trucks and buses (ANSI/ASSE 2006). Dr. Pratt has been an active member of the Z15 Committee since its formation in 2001. The standard covers management commitment and leadership; policies for managing drivers, vehicles, and the operating environment; incident reporting, review, and analysis; and sample policies for business and personal use of vehicles owned, leased, or rented by the company. In 2012, ANSI approved the first revisions to the standard (ANSI/ASSE 2012). Major changes include stronger guidance on seat-belt use, broader employer responsibilities for fatigue management, a new section on journey management, and expanded information on distracted driving, including a sample employer policy.

At the international level, the Division has contributed to the consensus standard ISO 39001:2012, *Road Traffic Safety (RTS) Management Systems – Requirements with Guidance for Use*. ISO 39001 was designed for use by any public or private organization that wishes to improve its road safety performance, develop and implement a road safety management system, and check its progress toward road safety targets. ISO 39001 is relevant for organizations that transport goods or people, or whose employees or contractors interact with the road system in any way in the course of doing business. Like the ANSI Z15.1 standard, ISO 39001's requirements are placed within a framework of roads, vehicles, and users. The main body of the standard is supplemented by non-mandatory appendices that provide guidance for implementation (International Organization for Standardization 2012).

Global Work

The Division is also engaged in global initiatives for occupational road safety as part of NIOSH's mission to provide global leadership in occupational safety and health. NIOSH and the Division participate in the UN Road Safety Collaboration (UNRSC), and provide input to UN resolutions and reports on road safety. Through the UNRSC, the Division has identified over 200 road safety management resources from around the world, which are freely available at http://www.fleetsafe.org/page/74.aspx, a Web portal hosted by the British non-governmental organization (NGO) RoadSafe. The Division also provides technical assistance and exchanges information with international partners such as EU-OSHA, and with government agencies and NGOs in the UK, France, Sweden, Australia, Mexico, India, and other locations.

Summary

ASSE and its members are important partners to NIOSH and the Division of Safety Research. NIOSH and the Division recognize the important leadership role that ASSE plays, and the collective contributions of ASSE members to improving worker safety on a day-to-day basis. NIOSH and the Division welcome ASSE and member input on our research throughout the research continuum, from project conception to translating research into practice. We appreciate

the opportunity to share some of our latest research at the ASSE Professional Development Conference, and hope ASSE members find them useful in their frontline work to improve worker safety.

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