

## **CONSTRUCTION-RELATED PRESENTATIONS FROM THE OCTOBER, 2009 NATIONAL OCCUPATIONAL INJURY RESEARCH SYMPOSIUM (NOIRS)**

NOTE: See <http://www.cdc.gov/niosh/noirs/2008/abstracts2008.html> for full list of all abstracts

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Session: **A1.0**

**Title: Describing and Preventing Falls From Heights in Construction**

Moderator: Paul Becker

### **A1.1**

**Title: Observation of Fall Risks in Residential Construction Sites**

Authors: **Kaskutas V**, Dale AM, Lipscomb H, Gaal J, Fuchs M, Nolan J, Patterson D, Evanoff B  
Introduction: Workers are exposed to many fall risks at residential construction sites. Methods to quantify these risks are needed.

Methods: Two experienced journeymen carpenters used a 52-item validated observational audit to evaluate the fall prevention behaviors of unionized carpenters at residential construction sites in the St. Louis area. Collaboration with the local carpenters' apprenticeship program, a joint union/contractor partnership, facilitated access to worksites. We computed the frequency of observations meeting the audit safety criteria.

Results: Multiple stages of construction were assessed at 197 worksites representing small, medium, and large contractors. Ladders were observed at 72% of the sites; however, extension ladders were not secured 88% of the time and stepladders were used inappropriately 49% of the time. Carpenters stood and balanced on 3½-inch boards, one story in the air while installing floor joists and roof trusses 81% and 93% of the time, respectively. Unprotected walking surfaces were identified with a warning line 18% of the time, and controlled access zones met OSHA guidelines only 2% of the time. Other operations met the criteria for safe work practices consistently. All of the pump jacks observed met safety criteria and roof slide guards were installed correctly 81% of the time. Fall protection equipment was set up correctly but was in use at only 5% of the site.

Conclusions: Fall prevention work practices are performed inconsistently at unionized residential construction sites in the St. Louis area. Nonunionized workers may be exposed to even greater fall risks as they rarely participate in formal training programs and may lack other workplace protections. Many of the observed risks could be controlled if safe work practices were followed. Improper ladder use is of concern as ladders are commonly used and ladder use accounts for a large proportion of falls in national injury statistics.

### **A1.2**

**Title: Interventions for Overhead Drilling in Construction**

Authors: **Rempel D**, Star D, Barr A, Gibbons B

Introduction: Overhead drilling into concrete or metal ceilings is a common task in commercial construction. It is associated with a risk of falls from ladders and acute arm injuries due to high torques applied to the arm when the drill bit seizes. This project developed, field tested, and refined interventions for overhead drilling that would decrease ladder use and reduce risk of acute injuries to the upper extremities.

Methods: The project was conducted in three phases. Each phase involved (1) the development of two or more prototype interventions with input from construction workers; (2) formal field evaluation of the usability, productivity, and safety features of the interventions by construction workers performing overhead drilling in the field; and (3) incorporating recommendations from workers in the next generation of device designs.

Results: In Phase I, an inverted drill press and a foot lever design, each able to reach ceiling heights of 11 feet, were compared the usual method for overhead drilling (N = 20). In Phase II, the inverted drill press design was evaluated with three different mobile bases against the usual method (N = 14). In Phase III, the inverted drill press design with a double column, to reach

ceiling heights of 15 feet, was evaluated against the usual method (N = 16). The Phase I devices were rejected by construction workers based on usability and productivity ratings. The Phase III device design was preferred over the usual method across all measures.

Conclusions: Field testing by experienced construction workers and their feedback on design was vital to the successful development of the intervention devices. It is difficult to anticipate how interventions will perform without testing in varied field settings. Designers of health and safety interventions should include an adequate number of rounds of testing and design modifications before settling on a final design.

### **A1.3**

#### ***Title: Development of a Unique Fall-Prevention Guardrail System for the Construction Industry***

Authors: **Bobick T**, McKenzie T, Cantis D

Introduction: During 1998–2005, an average of 154 workers were killed and 3,374 were seriously injured each year in all U.S. industries after falling from unprotected roof edges or through unguarded holes and skylights. These occurred primarily in construction. Various products are available to guard unprotected roofs, decks, or other interior surfaces. Some are used only on flat surfaces, while others are used on sloped roofs but are adjustable for just a few roof pitches.

Methods: Previous NIOSH research investigated the strength of job-built guardrails and two commercial products as perimeter guarding. A laboratory test was developed that used a weighted manikin mounted on a hinged steel frame to evaluate guardrails according to current OSHA regulations that require the top rail to support a 200-lb force.

Results: Output from the initial study is a unique patent-pending design of an adjustable roof bracket and guardrail system. Extensive laboratory tests indicated the bracket-rail assembly supported a dynamic load of 435 lbs, more than twice the OSHA requirement of 200 lbs at top rail. The NIOSH system is unique since it can be used to guard roof edges and holes, easily moved upslope where extra protection is needed, and used in the interior to guard stairwell openings or as a temporary stair handrail. The new design is adjustable for seven roof pitches, from 6/12 (27°) to 24/12 (63°, or Aframe), three of which are steeper than 45°. Discussions have been initiated with potential manufacturers to establish a partnership to produce this safety device commercially.

Conclusions: When commercially available, residential and industrial-commercial construction workers will have an all-purpose fall-prevention system. If used routinely, it has the potential of preventing dozens of deaths and hundreds of serious injuries caused by falling from heights.

### **A1.4**

#### ***Title: Plantar Vibration Effects on Postural Balance at Elevation***

Authors: **Simeonov P**, Hsiao H, Powers J, Ammons D, Amendola A, Kau T-Y

Introduction: The risk of falls from height on a construction site increases in conditions degrading workers' postural control. At elevation, workers depend heavily on sensory information from their feet to maintain balance. Recent research suggests that low levels of mechanical vibration to the feet may be beneficial for balance control. This study investigates two hypotheses: (1) sensory-enhancement—undetectable (subthreshold) mechanical vibration at the feet improves worker's balance at elevation,

(2) sensory-suppression—detectable (suprathreshold) mechanical vibration degrades worker's balance.

Methods: Twelve construction workers were tested while standing in different postures on instrumented insoles, which applied subsensory and suprasensory levels of random mechanical vibration to the feet. The tests were conducted in a virtual reality system simulating balance-challenging construction environment—i.e., a narrow plank on a residential structure. Upper body kinematics was assessed with a motion-measurement system. Postural stability effects were evaluated by conventional, “random walk,” and angular-displacement sway measures.

Results: The analysis did not confirm the “sensory-enhancement” hypothesis, but provided evidence for the “sensory-suppression” hypothesis. The results indicated that plantar-vibration effects were significantly modified by posture. Subsensory vibration slightly reduced some sway measures in the standard posture but significantly increased them in the semitandem posture.

Suprasensory vibration increased some sway measures across all conditions; however, the increase was considerably larger in the semitandem posture and affected most of the sway variables.

Conclusions: Sensory suppression associated with detectable levels of mechanical noise to the feet may increase the risk of losing balance. Workers on an elevated construction site might be at increased risk of falls if they can detect vibrations under their feet. To reduce the risk of losing balance, mechanical vibrations in the supporting structures should be minimized when performing tasks at elevation.

Session: **A2.0**

**Title: Cutting Edge Research: The NORA Intervention Evaluation Contest**

Moderator: James Collins

### **A2.1**

**Title: Applying Research to Practice: Anti-Vibration Interventions in Sheet Metal Assemblers**

Authors: Dale AM, Rohn AE, Shannon W, Standeven J, Patton A, Dods B, Kilwin J, Hoeckelman L, Braunschweig L, Kick T, **Burwell A**, Evanoff B

Occupational vibration exposure is associated with neurological and musculoskeletal injuries to the upper extremity. This study presents evaluation results for several anti-vibration gloves and an anti-vibration wrap used with vibrating sheetmetal fastening tools and discusses implementation of policy changes related to study results in a large manufacturing setting. Three experienced sheetmetal workers performed a series of fastener installations with a bare hand and six separate vibration-damping hand protection interventions. Two tri-axial accelerometers recorded vibration energy at the tool handle and on the back of the hand. Subjects completed a usability questionnaire following each intervention. Mean vibration from the hand showed reduced vibration ( $p < 0.001$ ) for all six interventions (range= 0.31-0.57Gs) when compared to the bare hand condition (1.32 Gs). Worker surveys showed positive feedback, with a preference for gloves with full fingers and gloves with wrist support. Our study showed that the tested vibration damping gloves and wraps consistently reduced vibration values during the specific work conditions measured at the hand. Following study completion, the company instituted a policy mandating the use of an anti-vibration glove or wrap during metal fastening or drilling operations for selected job categories. Early observations demonstrate growing acceptance among plant staff for the new policy. Evaluating interventions under real work conditions and providing workers a choice of interventions may enhance acceptance and support policy changes regarding personal protective equipment use.

### **A2.2**

**Title: Prevention of Traumatic Nail Gun Injuries in Apprentice Carpenters: Use of Population-Based Measures to Monitor Intervention Effectiveness**

Authors: Lipscomb H, Nolan J, Patterson D, **Dement J**

Introduction: Nail guns are responsible for a significant proportion of injuries in residential construction. The injury burden is particularly high among apprentice carpenters; this is due in part to their more common use of the tools.

Methods: Nail gun injuries were monitored over 3 years among carpenters enrolled in two apprenticeship programs in the Midwest following initiation of training and an ANSI standard change calling for safer sequential triggers on framing nailers. Injury rates, based on reported hours of tool use, were calculated yearly. Information on exposure to training through their apprenticeship program and elsewhere, including mentoring, toolbox talks, etc., was also monitored. Rates and adjusted rate ratios were calculated with Poisson regression methods. Attributable risk percent and population attributable risk measures were calculated yearly for modifiable independent risk factors for injury including lack of training in tool use and type of trigger mechanism on tools.

Results: As more apprentices received training and safer trigger mechanisms became more widespread, injury rates per 10,000 hours of tool use decreased significantly (31%). The largest decline was seen in the first follow-up year. While school training and mentoring were both

important, injury rates were lowest among apprentices who received both types of training. Although injury rates changed over the observation period, the relative risk comparing trigger mechanisms (contact vs. sequential) did not; contact trip triggers consistently carried a two-fold risk.

Discussion: Although training and safer trigger use both increased over time, because of the relative prevalence of training and trigger exposures in this population, the engineering solution consistently had the potential to make more difference in population risk than training. Our findings demonstrate the utility of observational methods including measures of population-based risk in evaluating the effectiveness of interventions and making recommendations for continued improvement.

### **Session: B1.0**

#### ***Title: Assessing Risks and Interventions in Fall Prevention***

Moderator: Alfred Amendola

#### **B1.1**

##### ***Title: Michigan Focus on Fatal Falls: Factors, Fixes and Follow-up***

Author: **Chester D**

Introduction: The Michigan State University Division of Occupational and Environmental Medicine, Michigan Fatality Assessment and Control Evaluation (MIFACE) Program, has been tracking traumatic work-related deaths in Michigan since 2001.

Methods: MIFACE has compiled the number of Michigan work-related fatal injuries, determined the means of death, and gathered additional information for each fatality. We will present the descriptive epidemiological data of work-related falls, highlighting fatal falls in the construction sector where 60% of the deaths from falls occurred. We will also present illustrative case studies, educational interventions, and implications for policy.

Results: In Michigan, there were 875 work-related deaths for the six years of 2001–2006. One hundred twenty-five (14.3%) of the deaths were a result of a fall. The other major industrial sectors for fatal falls, besides construction, were manufacturing with 9% and agriculture with 7% of the deaths. Roofers and roofer helpers were the occupational group in construction most likely to experience a fatal fall (20 of 75), followed by carpenters (9 falls), and painters and construction laborers (7 falls each). Nine of the 125 falls occurred to individuals identified as Hispanic. Six of these individuals were performing construction activities. Only 4% of the fatal-fall events involved women. Falls of less than 10 feet accounted for 33% of all fatal falls. Most fatal falls occurred from a scaffold or ladder (26 of 116 falls with known fall surface). Eighteen (25%) of 72 with a known fall surface in construction occurred from a scaffold or ladder. Of the 84 cases where the surface was known, the surface conditions may have been a factor in 20 falls.

Discussion: Fatal falls continue to be an area of concern. Effective intervention activities and collaborations are needed to reduce the incidence of fall events.

#### **B1.2**

##### ***Title: Fall-Safe Intervention Research, Final Results***

Authors: **Becker P**, Fullen M, Takacs B

Introduction: Falls are the leading cause of morbidity and mortality in the construction industry. Technology is available but not commonly used to prevent substantial numbers of these falls. This intervention research project hypothesizes that a third party (university, insurance company, nonprofit) can market a program that decreases fall hazards and the incidence of fall on construction sites.

Methods: The Fall-Safe fall hazard management system was provided through West Virginia University, St. Paul Insurance, and Construction Safety Council to 63 contractors. The program consists of training, written and site programs, employee feedback, and weekly site inspections. The program employs third-party audit using a hand-held device to establish compliance with OSHA standards for falls. Scores (arithmetic percent of control measures correctly implemented) on quarterly inspections by the third party provide feedback to contractors on how they are managing fall hazards. A control group of contractors did not receive training but was monitored by the third parties for changes in hazard control scores. A variety of metrics measures difference

in hazard control score from a preprogram baseline to post-training implementation and compares the changes between intervention and control contractors.

Results: Program contractors improved their hazard control scores significantly more than control contractors.

Discussion: A quasi experimental experiment indicates that third parties can market and implement organizational interventions with construction contractors that result in improvements in hazard control by the intervention contractors.

### **B1.3**

#### ***Title: Effect of Side Forces on the Stability of Scissor Lifts***

Authors: **Pan C**, Chiou S, Powers J, Cantis D, Ronaghi M, Boehler B

Construction work is one of the leading fatal occupations. Seventy-four percent of scissor lift fatalities occurred in the construction industry. Previous research evidence indicates that falls were major causes of fatalities related to scissor lifts. In addition, constructing and repairing activities contributed to almost half of scissor lift falls. Operator activities within the platform, such as pushing a drill and pulling wires, create excessive side forces leading to the instability of scissor lifts. The objective of this study was to examine the effect of side forces generated by operator activities on the overall stability of scissor lifts. Twenty construction workers (mean age:  $42.3 \pm 7.7$  years) participated in this study. Maximum side forces were measured while subjects performed simulated construction tasks on the main or extension platform in three standing directions. The experiments were conducted at three levels of lift heights (39, 56, or 72 inches). Three accelerometers were attached underneath the scissor lift to simultaneously determine the lift stability. The greatest side force observed among 1,080 trials was 140.85 lbs. Results from repeated-measure ANOVAs revealed that the height of the scissor lift did not affect the maximum side forces exerted by the subjects, implying high side forces may occur at any level of height. Pushing tasks produced significantly greater side forces than pulling tasks ( $p < 0.0001$ ). Tasks performed in a standing direction parallel with the length of the lift created the greatest side forces ( $p < 0.0001$ ). Significantly greater lift acceleration was also found while subjects performed tasks in the direction parallel with the lift at either 56 or 72 inches of height. This study provides important information on the magnitudes of side forces generated by operators as well as how standing directions affect side forces and the stability of scissor lifts.

### **B1.4**

#### ***Title: Development of Improved Harness Sizing System***

Author: **Hsiao H**

Introduction: Updated fall-arrest-harness designs are needed to accommodate diverse populations in the current workforce, and the successful design of efficient harnesses relies on quantitative data of human body shape variation. This study determined (1) body shape factors that associated with harness-fit problems, (2) the most favorable number of harness sizes, and (3) the adjustable range for each harness component for harness design.

Methods: An Elliptic Fourier Analysis (EFA) procedure with 123 coefficients was developed to quantify torso-shape effect on harness fit, using 3-dimensional torso scan data of 108 women and 108 men.

Results: The EFA coefficients were then applied to 600 representative body scans from a national database of 2,382 participants to establish an improved sizing system.

Conclusions: The study identified that increased inclination of torso suspension angle (hence fit failure) was associated with a reduction in torso length and a more developed chest; harnesses for women can be designed with a more upward back D-ring than that of the current unisex design to mitigate this problem. Study outcomes also suggested a system of 3 sizes for women and 3 sizes for men, of which the adjustment ranges of the torso straps were approximately within 17 cm and the thigh and hip straps within 23 cm. This research could help reduce the risk of worker injury that results from poor fit, improper size selection, or the failure to don the harness properly.

Session: **C1.0****Title: Ladder Safety**

Moderator: Hongwei Hsiao

**C1.1****Title: Prevalence of Hazards Associated With Falls From Stepladders and Targets for Intervention**Authors: **Ronk CJ**, Dennerlein JT, Perry MJ

Introduction: Falls are a leading cause of fatalities in construction, and ladder fatalities have increased in recent years. There are many factors associated with falls from portable ladders; however, targets for intervention are unclear. Our goal was to measure the prevalence of known hazards in the construction environment in order to later conduct a targeted intervention.

Methods: An assessment tool was developed to measure compliance with portable ladder use best practices using items compiled from standards, guidelines, and reviews with safety professionals and researchers. Trained researchers observed stepladders at 19 sites of eight general contractors in the Commonwealth of Massachusetts. Ladders were scored on overall condition (n = 772), setup (n = 401), workers' movements (n = 140), and completion of tasks (n = 160) while using ladders.

Results: 96% of stepladders were Type I rated and free of defects. 87% had their bottoms clear of tripping hazards and 95% had spreaders locked. For the workers' movements score, 73% maintained three points of contact, 87% moved slowly, 49% had hands free, and 92% checked stability prior to climbing. For the completion-of-tasks score, 88% of ladders were the proper height for the job task, 91% of workers faced the ladder, 86% stayed within the horizontal support (i.e., belt-buckle rule), and 77% used minimum forces.

Discussion: Our assessments showed that most of the sites had stepladders of good quality and their setups regularly had spreaders locked. However, full compliance with best practices was not seen for several factors especially having hands free while climbing and using minimum forces. As a next step, we plan to focus on these delinquent areas as part of a targeted intervention to reduce falls from portable construction ladders.

**C1.2****Title: Portable Ladder Tool Development and Validation—Quantifying Best Practice in the Field**Authors: **Dennerlein J**, Ronk C, Perry M

Introduction: While many efforts have developed specific design standards for ladders, many of the causes for falls from ladders are related to the use of practices. Therefore, we developed and tested a tool that assesses portable ladder best practices.

Methods: The questions were compiled from standards, guidelines, and review with safety professionals and researchers. Implemented on a hand-held computer, the assessment tool consisted of a series of checklists categorized in four best-practice categories: product condition, setup, moving on and working on a ladder. Three trained individuals scored a set of photos and videos depicting 25 ladder quality, 20 ladder setups, 10 moves on ladders, and 13 working on ladder observations (78 total).

Results: The resulting best-practices assessment tool contained 31 and 33 questions for all four observational classes for the step and extension ladders, respectively. Scoring all four categories takes approximately 2 to 3 minutes to complete. The practice assessment tool had good agreement across and within raters. For the yes/no responses to the 78 ladder observations, the inter-rater agreement ranged from 79% to 97% across the four observation classes and the three raters. The corresponding Kappa coefficients ranged from 0.41 to 0.83 with half greater than 0.75 indicating good to excellent agreement across the raters. For the one rater who completed that task twice with six-weeks between evaluations, the reproducibility of scores were excellent with percentage of yes/no responses in agreement greater than 89% and Kappa coefficients greater than 0.78.

Conclusions: The tool provides a method to quantify best practices associated with ladder use. Implementation can assist both the researcher and the practitioner in the prevention of falls related to ladder use.

**C1.3****Title: Can a CSA Standard Certified Type-2 Ladder Design Hold a 0.41m Free Fall?**Authors: **Varrasso B**, Vi P

Introduction: One ideal to prevent the risk of falls is to tie-off to a ladder rung so that the users can maintain 3-point contact when working. To test the feasibility of this ideal, it is important to test the strength of the rungs to determine if the rung can handle the forces associated with a fall.

Methods: A 7.62 m CSA Type-2 aluminum extension ladder was placed against a work surface at an angle of 75 degrees. A 100 kg mass was hung from the ladder, raised 0.41 m vertically, and then released. To test the strength of the ladder rung, two tie-off methods were applied: (1) the mass was hung from a cable attached directly to the center of a rung approximately 6.1 meters from the base support, and (2) the mass was hung from a rope wrapped around both side rails at the same height as in the first method. The portable ladder was secured top and bottom to prevent the ladder from sliding under load.

Results: When six dropped tests of a force of ~5.4 kN was applied to the center of the rung, visible damage to the rung was observed. However, the ladder rung did not shear in half or release the load. Another six dropped tests were conducted using the rope-wrapped-around-the-rails method. There was no observable damage to the ladder rung and rails under dynamic load.

Conclusions: A typical aluminum CSA Type 2 ladder under load did not fail when the rope-wrapped-around-rails method was used. Therefore, the feasibility of working on ladder can be possible if the users use the rope-wrapped-around-the-rails method and fully secure the ladder at the top and bottom. Further studies should be conducted to verify this finding.

**C1.4****Title: Effect of Ladder Types on Energy Expenditure, Forearm Force Exertion and Climbing Behavior**Author: **Vi P**

Introduction: Fixed vertical ladders can present safety risks for slips and falls because of their design, the ladder's location, and exposure to environmental factors (wet/icy weather and bird droppings). Adding to this risk is the potentially higher energy expenditure and high forearm exertion required to climb a ladder in a vertical orientation. The main purpose of this project was to evaluate the differences in climbing behavior, energy expenditure, and forearm exertion when climbing fixed vertical ladders and portable extension ladders.

Methods: Twenty workers participated in this study. A simulated ladder climbing task was used to investigate the energy expenditure and forearm force exertion while climbing on a 20-ft portable extension ladder (placed at 75 deg to a work surface) and a fixed vertical ladder. While performing a ladder-climbing task, participants were video taped, and heart rate and forearm force exertion of the forearm flexor muscles were quantified.

Results:

- Climbing on portable and fixed ladders required a mean energy expenditure rate of 11.4 kcal/min and 13.1 kcal/min, respectively (significantly different at  $p < 0.05$ ).
- The forearm force exertion was also found to be significantly ( $p < 0.05$ ) lower when participants climbed on the portable ladders.
- Ten percent (10%) of the 20 participants used a 3-point contact technique when climbing the vertical fixed ladder. For portable ladder climbing, however, 80% of the participants maintained 3-point contact.

Conclusions: Due to the higher energy expenditure, greater forearm force exertion, and 2-point contact climbing technique, repetitive climbing on a vertical fixed ladder is more likely to increase the occurrence of whole body fatigue, localized forearm muscle fatigue, and higher risk of slip and fall than climbing on a portable ladder. Given these findings, it is recommended that workers should use appropriately secured portable ladders when the work environment permits.

Session: **C3.0****Title: Characterizing and Preventing Injuries to Hispanic Workers**

Moderator: Cammie Chaumont Menéndez

**C3.3****Title: Preventing Hispanic Fatalities**Author: **Casini V**

Introduction: The Bureau of Labor Statistics estimated there were 19.6 million employed Hispanics in 2006, making up almost 14% of the U.S. workforce. By 2016, the Hispanic workforce is expected to increase to nearly 27 million, an increase of almost 30%. Since 1992, the number of Hispanic worker fatalities has steadily increased. In 2006, Hispanic workers experienced a high number and rate of deaths, with 937 fatalities and a rate of 4.7/100,000 workers, compared to a rate of 3.9 for workers of all races/ethnicities. In an effort to reduce this fatality rate, the NIOSH Fatality Assessment and Control Evaluation (FACE) Program has included Hispanic worker fatalities as a target for investigation.

Methods: The FACE Program investigates fatal workplace incidents with the goal of identifying effective prevention measures. Through on-site fatality investigations, FACE personnel collect agent, host, and environmental information from the pre-event, event, and post-event phases of the fatal incident. The FACE program is a case-series design to facilitate descriptive analysis of the incidents and the development of preventive recommendations.

Results: To date, NIOSH personnel and state programs with NIOSH cooperative agreements have investigated 240 fatal occupational incidents resulting in the deaths of 249 Hispanic workers, occurring mainly in agricultural and construction. Problems identified include assignment to dangerous tasks, language and cultural barriers, lack of training, false credentials used by youth to gain employment, assignment of youth to tasks prohibited by child labor laws.

Discussion: FACE results indicate that training in safe work procedures and hazard recognition should be provided in a language and at a literacy level that all workers can comprehend. Employers should fully evaluate worker competency and age before assigning work tasks. Employers should consider the cultural issues when communicating safety information.

**C3.4****Title: Fatal Occupational Falls Among Hispanic Construction Workers, 1992–2006**Authors: **Dong S**, Men R, Fujimoto A

Introduction: Falls are the leading cause of death in construction, accounting for about one-third of all work-related deaths in this industry. In recent years, although the overall death rate of construction workers has declined, the number of deaths among Hispanic construction workers has increased. The safety and health of Hispanic workers is a critical challenge for the construction industry due to implementation, enforcement, and language barriers among Hispanic workers. This study aims to address important issues concerning this vulnerable population.

Methods: Two large national datasets, the Census of Fatal Occupational Injuries and the Current Population Survey collected by the U.S. Bureau of Labor Statistics, were used for this study.

Univariate and multivariate analyses were conducted using SAS (version 9).

Results: The number of deaths resulting from fall injuries among Hispanic construction workers increased dramatically during the study period. Fatal falls accounted for nearly 40% of the total deaths among Hispanic workers, much higher than the 31% for non-Hispanic workers. Fatal falls were the most prevalent among younger Hispanic workers. In 2006, nearly half of the victims of fatal falls were less than 35 years old among Hispanic workers compared with about 20% among non-Hispanics in the same age group. During the study period, 99% of fatal falls among Hispanic workers were caused by falls to a lower level, which was higher than the percentage for non-Hispanic construction workers.

Conclusions: Hispanic construction workers, especially younger Hispanic workers, have a higher risk of work-related falls than their non-Hispanic counterparts. Prevention strategies to reduce fall injuries and fatalities should focus on young Hispanic construction workers.



**POSTER SOCIAL**  
**Construction Safety**

**P01*****Title: Self-Reported Postures and Task Parameters within the Construction Industry that Lead to Instability Upon Standing***

Authors: **DiDomenico A**, McGorry RW, Blair MF, Huang Y-H

Introduction: Falls within the construction industry are numerous and potentially have severe injury outcomes. Loss of balance is a primary causal factor for injuries related to falls. One contributor may be movement necessary to transition from a working posture to a standing position. The movement can affect physiological systems and it is unclear as to which postures evoke the strongest response and make it difficult to remain stable.

Methods: A written survey was administered to ~150 construction workers within building trades. Using input from subject matter experts, the research team developed survey items regarding occupational postures, levels of instability upon standing, and factors that affect balance.

Instability was rated on a 5-point Likert scale. Questions were also included to identify which task parameters were believed to make maintaining balance most difficult.

Results: Eleven working postures were evaluated with a mean stability rating of 4 (SD 0.26), indicating a somewhat stable rating. Squatting resulted in the most reported instability with a mean of 3.78. Protective measures were identified with nearly half (47.1%) of the participants signifying that they hold on to an object to maintain balance. Other protective measures included, for example, pausing after standing up (37.8%). The top three factors that made maintaining balance difficult were fatigue (52.5%), standing up fast (46.4%) and working on an uneven or irregular surface (43.9%).

Discussion: Construction workers studied had good to excellent self-reported balance but still indicated that they had occurrences of instability upon standing. Due to the hazardous work environments at construction sites, maintaining stability while working is crucial. It is unknown if workers accurately perceive the level of instability during a workday. Future research will compare these findings with objective measures of stability and determine how well subjective measures represent actual risk.

**P02*****Title: Incidence Patterns of Lost Time Injuries within a Large Population of Construction Companies***

Author: **McVittie D**

Ontario's construction industry consists of almost 60,000 employers, ranging from very large to very small. The Lost-Time Injury experience and Insured Hours Worked for this large population was examined to discern multi-year incidence patterns over an 8-year period.

The data on Lost-Time Injuries, and Insured Hours Worked was extracted for all firms that reported any LTIs during the period 1998-2002. Each year's cohort of injury-incurring firms was followed for 4 additional years to observe which ones incurred injuries in subsequent years. The proportion of firms that incur multiple years with higher than average LTI rates are shown.

Approximately 3% of the injury-incurring construction firms (or 0.021 % of all construction firms) experience higher-than-average LTI rates in 5 consecutive years.

Most construction firms that incur an LTI in any given year are unlikely to incur another one for several years. The cohort of injury-incurring firms in any year consists primarily of firms that did not have any LTIs in the prior year and are unlikely to have another one in the next year.

The pattern is very consistent within the different multi-year cohorts examined in this study.

The significance of these findings impacts on targeting company-level interventions.

Regulatory agencies and prevention organizations can focus high-intensity interventions on a relatively small population of firms that have consistently "worse-than-average" experience in order to maximize the effect of limited resources.

Regarding the large number of companies which incur a single LTI, and which may not likely incur another one for several years, a more time-sensitive approach is needed.

Conventional public health model approaches can be integrated with a more focused intervention strategy

**P03*****Title: Improvements in Injury Rates in Construction - 1998-2006***Author: McVittie D, **Varrasso B**

The overall rate of lost time injuries in Ontario's construction industry has improved by more than 33% from 3.48 /200,000 hrs in 1998 to 2.34/200,000 hrs in 2005.(2006 and , if available, 2007 data will be included).

Three major types of accidents account for 95% of all LTIs in construction: overexertion/repetitive motion struck by/against objects, and falls.

The rate of improvement for each of these major types of accidents during the period 1998-2006:  
LTI rate improvement

Overall LTI rate 33%

Overexertion/repetitive motion 31%

Other single traumatic event: injuries 30%

Falls 39%

Other single traumatic event injuries include struck by, struck against objects, contact with objects, caught in/on/between objects.

The increased emphasis on fall prevention during this period appears to be having a positive impact on reducing the incidence of fall-related injuries.

The other types of accidents are also improving despite unprecedented growth in construction employment (up 70% since 1998).

Charts showing the pattern of change during this period are provided.

**P04*****Title: Claim Persistence and Cost Measures for a Large Population of Construction Disability Cases***Author: McVittie D, **Fiorini D**

Data on all lost time injury claims registered with the WSIB for the period 1998-2006 inclusive were extracted to examine the proportion of claims from any given year which incurred costs in any subsequent year(s). The total costs for those claims in each of the subsequent years were also extracted.

The proportions of each year's cohort of claims which incurred costs in subsequent years were determined.

The average costs per original year claim were also determined for each subsequent payment year.

The analysis shows some minor increase in the proportion of claims incurring costs in subsequent years (suggesting that "simple easy-to-prevent injuries are diminishing more rapidly than more difficult ones). Cost analysis shows some quite variable results.

(Data to be provided in tables and charts)

**P05*****Title: Preventing Worker Deaths and Injuries from Contacting Overhead Power Lines with Metal Ladders***Author: **Romano N**

Introduction: A NIOSH review of the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) data from 1992–2005 identified at least 154 electrocution deaths that resulted from contacting overhead power lines with portable metal ladders (excluding truck-mounted and aerial ladders). Of these 154 deaths, 36 involved a person of Hispanic origin (CFOI data for all years exclude New York City; the data for 2005 are preliminary).

Methods: The NIOSH Fatality Assessment and Control Evaluation (FACE) Program identifies and studies fatal occupational injuries, with the goal of identifying effective prevention measures.

Through on-site fatality investigations, FACE personnel collect agent, host, and environmental information from the pre-event, event, and post-event phases of the fatal incident.

Results: A review of NIOSH FACE cases between 1987 and 2007 identified 11 investigations involving the deaths of 12 workers that occurred while working around overhead power lines and using metal ladders. Ladder contacts with power lines usually occurred during erection, lowering,

or relocation of the ladder. Some examples of preventive recommendations from these investigations are: (1) employers eliminating use of conductive ladders, (2) employers developing a comprehensive safety and training program in language(s) and reading levels of the workers, (3) manufacturers affixing bilingual labels with graphics to provide hazard warnings and instructions.

Conclusions: Evidence collected during FACE investigations suggests that the victims may not have been fully aware of the hazards to which they were exposed, and that employers did not have adequate safety programs and training to address this hazard. In order to lower fatality rates, workers must be informed of the potential hazards present and should receive training to perform their tasks in the safest possible manner.

#### **P06**

##### ***Title: Review of Research on Disability in Construction***

Authors: **Becker P**, DiSalvo C

Introduction: Numerous articles have been published in the last 5 years reporting causes and conditions of disability (and particularly disability prior to normal retirement age) among construction workers. In some cases these articles note risk factors associated with these disabling conditions. An overview of the reported disability experience of construction workers can help focus on controlling hazards contributing to these disabilities.

Methods: Review peer review literature in peer review journals and government reports on incidence and risk factors associated with disability among construction workers. Construct a table summarizing these findings.

Results: There is now substantial evidence that there are several leading causes of disability among construction workers. Identification these conditions and associated risk factors focuses attention on priority areas for control.

Discussion: There is wide anecdotal evidence that many construction workers retire early due to disabling conditions. This poster provides baseline data confirming the need for the development of focused research on early disability among this population. We may find the need to develop a contrarian hypothesis about aging and physically demanding work which counters the prevailing hypothesis that aging causes workers to fall short of strenuous job demands. The alternative hypothesis might be that strenuous work is prematurely aging (and disabling) a particular workforce (worn out worker.)

#### **P07**

##### ***Title: Crane-Related Fatalities in Construction, 1992-2006***

Author: **McCann M**

Introduction: Recent tower crane collapses with multiple deaths in New York City and Miami have generated concern about crane safety and the risk to the public in general. The purpose of this study is to analyze the causes of crane-related deaths in construction.

Methods: Crane-related deaths were identified by selecting all construction records from 1992-2006 with source or secondary codes of "crane" (343\*) from the Census of Fatal Occupational Injuries Research File of the Bureau of Labor Statistics. The records were analyzed for causes of death and occupation.

Results: A total of 315 crane-related worker deaths were identified, about 21 deaths per year. Major causes of death were contact with overhead power lines (32%), falling/collapsing cranes (19%), struck by crane parts or loads (except falling booms) (23%), struck by falling crane booms (14%), and caught in/between (7%). Less than 10% of the crane deaths involved tower cranes. The main occupations of workers killed were construction laborers (30%), crane and tower operators (16%), supervisors/ managers/administrators (13%), other heavy equipment operators (7%), and mechanics (5%). In the overhead power line contact deaths, 29% of contact involved the crane boom, and 19% involved crane cables. Only about one-third of the CFOI narratives for falling/collapsing cranes indicated the cause of the collapse. Reasons listed included insufficient ground support, excessive loading, mechanical problems, and high wind. About 60% of the falling crane boom deaths occurred while assembling or dismantling the boom or part of the boom.

Discussion: Recommendations include: (1) a permit system for working near overhead power lines;

(2) required state certification of crane operators;  
 (3) following recommended procedures for assembly, disassembly and rigging of cranes; (4) following manufacturer's limits for loads; and (5) not working under (or allowing pedestrian or vehicle traffic under) suspended crane loads.

## **P08**

### ***Title: Nail-Gun Injuries Treated in Emergency Departments—United States, 2001-2005***

Authors: **Jackson L**, Lipscomb H

Introduction: Speed, ease of use, and ready availability have made pneumatic nail guns a common tool used in work settings such as residential construction and wood-product fabrication. In addition, the tools are now readily available to consumers, extending to the public what had been primarily a potential work-related hazard.

Methods: To characterize nail-gun injuries in work and nonwork settings, injuries treated in U.S. hospital emergency departments (EDs) were studied by using the U.S. Consumer Product Safety Commission's (CPSC's) National Electronic Injury Surveillance System (NEISS) and the NEISS occupational injury supplement (NEISS-Work) maintained by the National Institute for Occupational Safety and Health (NIOSH).

Results: During 2001-2005, an average of approximately 37,000 patients with injuries related to nail-gun use were treated annually in EDs, with 40% of injuries (14,800) occurring among consumers. In addition, in 2005, nail-gun injuries among consumers were about three times higher than in 1991 (4,200)—approximately a 200% increase. In 2005, most injured consumers and workers were men. The median age for injured workers was 27 years, and 35 years for consumers. The diagnosis associated with 87% of the nail-gun injuries was either wound with a foreign body or puncture wound.

Discussion: ED injury estimates provide a national perspective on the injuries received from nail guns and indicate how injuries from tools used in work and nonwork settings can overlap. Although training regarding safe work practices might reduce nail-gun injuries, use of sequential-trip triggers is likely to be more effective. The current voluntary ANSI standard only addresses availability of the sequential-trip triggers. Distribution of new nail guns with sequential-trip triggers without the optional contract-trip triggers might help reduce nail-gun injuries.

## **P09**

### ***Title: Direct-Fired Construction Heater Emissions Study***

Authors: **Hopkins R**, Sahai D

Introduction: Direct-fired construction heaters release carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>) into the air where people work. Elevated levels of CO or CO<sub>2</sub> pose hazards to workers. The hazard may be greater for individuals with pre-existing medical conditions such as heart and lung disease, and for the fetus in pregnant workers. CO and CO<sub>2</sub> concentrations were measured on construction sites to ascertain if the ventilation practices were adequate.

Methods: Heated construction sites in Ontario were tested for levels of CO<sub>2</sub>, and CO during the winter of 2003/2004. Samples were taken of the ambient air and of the flue gas of each heater.

Results: Five heaters out of 84 produced ambient readings above the CO TLV of 25 ppm, reaching up to 95 ppm. Eleven heaters out of 84 produced ambient readings at or above the CO<sub>2</sub> TLV of 0.5% (5000 ppm), reaching up to 1.2%. There were no locations where the O<sub>2</sub> was measured below 19.5%. CO and CO<sub>2</sub> levels were generally higher at ceiling level. Infrared heaters emitted an average of 10 times more CO than did the salamander type heaters. Ambient readings of CO and CO<sub>2</sub> were higher in tight buildings (buildings with few openings to the outdoors).

Conclusions:

1. CO and CO<sub>2</sub> emissions can exceed their TLVs in tight buildings. Large industrial sites did not show these higher concentrations, nor did tarped-in sites. Even when well constructed, tarped-in sites apparently were not "tight."
2. Adequate ventilation requires meeting combustion requirements and removing emission gases. Workers must keep openings for ventilation clear, so emission gases do not build up.
3. Concentrations of CO and CO<sub>2</sub> need to be monitored more diligently in tight buildings.

4. All workers with pre-existing medical conditions and female workers that are pregnant need to be careful about exposures when in tight buildings.

#### **P25**

##### ***Title: The California Fatality Assessment and Control Evaluation (FACE) Program 1992-2005: Fatal Work Injuries Among Hispanics in Los Angeles County***

Authors: **Styles L**, Cierpich H, Harrison R, Rogge J

Introduction: The California Department of Public Health, in collaboration with the National Institute for Occupational Safety and Health, has established the California Fatality Assessment and Control Evaluation (FACE) Program for the surveillance and investigation of fatal work injuries. The California FACE Program focuses on Los Angeles County, where approximately 20% of all work-related fatalities in California occur. The goal of the FACE Program is to prevent fatal work injuries by identifying high-risk work processes, developing prevention strategies, and informing those who can intervene in the workplace. This presentation will focus on fatal work injuries among Hispanics, who are among the fastest growing segments of the U.S. workforce. Methods: The California FACE Program uses multiple sources of notification for the rapid identification of work-related injury fatalities. Cases for investigation are selected based on several factors, including the NIOSH FACE priority conditions of machine-related, youth under 18 years of age, highway/street work zone, and Hispanic workers.

Results: The work-related injury death rate for Hispanic workers during 1992-2005 was 3.8/100,000 workers compared with a rate of 2.7 for non-Hispanic workers. Deaths among foreign-born Hispanic workers were about 83% percent of the Hispanic work-related injury death total in 2005, up from 65% in 1992. Homicide was the most frequent event leading to work-related injury death among Hispanic workers from 1992 through 2005, followed by transportation-related, and falls. The most work-related injury deaths of Hispanic workers occurred in the construction (22%), services (20%), and retail trade (16%) industry sectors.

Discussion: The California FACE Program has completed almost 200 in-depth fatality investigations since 1992, and approximately half of these involve Hispanic workers. Select investigations will be highlighted, and recommendations for prevention will be discussed.

#### **P26**

##### ***Title: Pilot Surveillance Methods for Injuries Among Day Laborers***

Authors: **Lowry S**, Seixas N, Blecker H, Hecker S, Camp J, Arbabi S

Introduction: Injuries among day laborers are high, although these data are difficult to obtain due to informal work and transient populations. Two alternative approaches to injury surveillance among day laborers were explored: a hospital-based trauma registry, and active injury reporting in two day labor centers.

Methods: Hospital-based regional trauma registry was used to identify work-related injuries, 2001-2006. The database includes demographics and injury characteristics, however no further information on employment. Patient charts were reviewed to ascertain work characteristics and day labor status. Work-related cases were stratified by Hispanic ethnicity (87% of day laborers are Hispanic immigrants), and by presence of a social security number (~75% of day laborers are undocumented). Forty cases were abstracted in each stratum. Day labor status was coded for each case. Injury report forms were made available at two day labor hiring centers and solicited at weekly safety trainings from September through December 2007.

Results: Of the 1298 work-related injury cases identified, 89% were male; 86% were non-Hispanic. Four percent of non-Hispanics and 23% of Hispanics were missing social security number. Among Hispanics lacking a SSN, a larger fraction were day laborers compared to other groups. Employment information was largely missing from all groups. Over a 3-month period, 12 injury reports were received; more in response to specific inquiries than general requests, calling into question the validity and comprehensiveness of this approach.

Conclusions: Neither of these approaches to injury surveillance appears to be effective under the current systems. Trauma registry data lack work-related information, and only include severe injuries. The report form approach proved to be non-systematic and incomplete. Despite limitations of both approaches, they each provide insights into the problems associated with

precarious work risks. Recommendations for improving surveillance among contingent workers are provided.

Session: **D1.0**

***Title: Injury Prevention in Construction - I***

Moderator: Matthew Gillen

**D1.1**

***Title: Diffusion of Modular Home Installation Safety Work Practices as a Result of Field Research***

Authors: **Fullen M**, Takacs B, Becker P

Introduction: While conducting training a faculty member learned of hazards unique to modular home installation and investigated them as part of a case study. No previous research has been conducted on modular home installation safety hazards. This study included field research observations, video and photograph collection, interviews, and questionnaires. The study identified the hazards faced by workers that appear to be specific to modular home installation, recommends ways to improve worker safety, and suggests areas for future research.

Methods: This research involved conducting field research of four modular home installations as well as collecting worker, supervisor, and owner survey data regarding safety during the installation process. The field research results identified hazards specific to the industry. WVU developed and diffused industry-specific safety training based on the hazards identified as well as developing safe alternatives that included alternative work practices, use of existing technologies, as well as the introduction of conceptual tool designs. WVU also developed conceptual designs of two devices.

Results: The field research identified industry-specific hazards including the hoisting of heavy house modules with the use of a hydraulic crane, unique fall hazards, crushing hazards created by working under a tilt-up roof to secure it while a crane suspended the roof. The companies had not addressed any of the industry-specific hazards identified.

The hazards identified resulted in the development of training material that is currently being delivered through instructor-led and web-based training and is being evaluated for applicability and effectiveness.

Discussion: The process of installing a modular home is complex and dangerous. Site conditions, foundation location, and the type and size of the house can affect the potential for injury to employees. However, diffusion of knowledge through training, changes in house design, new technologies, and regulation could make this industry and process safer.

**D1.2**

***Title: Viability of Tying Off to Residential Roof Trusses for Fall Protection During Truss Erection***

Authors: **Fiorini D**, Garritano E

Introduction: Erecting preconstructed trusses in residential low-rise construction poses a challenge with respect to fall protection for the workers involved. Trusses need to be spread out along the roof, lifted into place, and braced to accept sheathing. In order to lift and brace the trusses, workers can be exposed to a fall of greater than 3 m (10 ft.) to the inside of the house. This study investigates the use of the trusses themselves as a viable fall arrest anchor while lifting and bracing all the trusses.

Methods: A residential frame was built with two walls approximately 7 meters apart (24 ft) on which trusses were erected. An end wall was built between the two walls parallel to the trusses. Trusses were erected in accordance with current practice. A rigid 100 kg (220 pounds) test mass was hung from the truss system, raised, and allowed to free fall. The truss system was observed for its ability to the dynamic forces associated with arresting the mass. The truss system bracing was modified until it was able to support the fall-arrest forces.

Results: To support the dynamic arresting forces, truss bracing must support tensile loads in addition to compressive loads. This was accomplished by using metal strapping over the braces secured into the truss chords. The toes of the trusses were stabilized by nailing two common nails adjacent to each side of the toe on the wall (allows adjustment to the truss but prevents

lateral kick-out). Tie off points at truss joints were found to be stronger than at mid chord positions.

Discussion: Adequately braced trusses can be stable and strong enough to withstand the forces associated with arresting the fall of a 100-kg mass (at a 7-m, or 24-ft clear span).

### D1.3

#### ***Title: Train-the-Trainer Training—A Case Study***

Authors: **Smith A**, Chen P, Rosecrance J

Introduction: Leadership plays an important role in injury prevention in any organization. For example, Zohar (2004) found that employee perceptions that supervisors support safety negatively related to occupational injuries. Research also supports that climate for error management and climate for safety communication predict safety behaviors and accidents on the job. The present study describes an intervention targeted at teaching supervisors in the construction industry how to support a climate for safety communication with their employees. Methods: The intervention took place at a large mechanical contractor in the northeast. Slides describing how to give appropriate feedback, positive recognition, and daily verbal exchanges emphasizing safety were added to the company's existing foreman orientation materials. Thirty-six site-level supervisors (e.g., superintendents, project managers) participated in a train-the-trainer session introducing the new foremen orientation materials, practiced delivering the materials, and were taught adult learning principles to incorporate into their orientation delivery to maximize foreman learning and engagement with the material. In addition, the site-level supervisors were introduced to a communication audit to be completed twice a month to support foreman transfer of training.

Results: The post-intervention assessment of communication climate and employee injuries will be conducted next month. These results will be ready for presentation. Pretraining and post-training surveys of participants indicated that utility perceptions of the train-the-trainer session were moderately high, most supervisors felt that the new content would improve safety on the job, and most participants intended to use the adult learning principles taught in their future delivery of the foreman orientation materials.

Conclusions: Interventions targeted at employee injury prevention in a construction setting should involve both the foreman level and the support of site-level management. We argued that training supervisors on how to support safety communication will have an impact on worker perceptions and injuries on the job.

### D1.4

#### ***Title: Demonstration of Proximity Warning Systems (PWS) to Reduce Worker Exposure to Asphalt Trucks at Highway Paving Operations***

Authors: **Beaupre JE**, Merinar TR, Fosbroke DE

Introduction: Between 1992 and 1998, the Census of Fatal Occupational Injuries (CFOI) reported 841 fatalities in the highway and street construction industry (Standard Industrial Classification 1611), accounting for 11% of all construction deaths over this period. The majority of fatalities in this industry occurred in work zones with 95% of the fatal events involving vehicles and equipment. In 318 of these fatalities (38%), a worker-on-foot (WOF) was struck by a vehicle, typically while backing (51%). The primary injury source for these WOF fatalities was a truck (61%). The objective of this study is to evaluate the efficacy of proximity warning systems (PWS) in reducing WOF exposure to dump trucks at asphalt paving operations.

Methods: The project involved the installation and evaluation of PWS on asphalt delivery trucks. Control and treatment data collection occurred for 6 to 8 days at each company. PWS, including sonar, radar, and camera, were installed on eight asphalt trucks at each of three companies. Data collection methods included global positioning system (GPS) receivers, video observations, and direct observations with the addition of alarm activation data on the treatment sites.

Results: Based on preliminary analysis of direct observation data, the site exposure rate declined by 18.8% from the preintervention rate of 30.3 (95%CI: 35.5–25.1) exposures per hour to the post-intervention rate of 24.6 (95%CI: 29.6–19.6) exposures per hour.

Discussion: Data show a reduction of WOF exposure to equipment, based on preliminary results gathered from direct observations at the site level. Though not statistically significant, these site-

level results provide evidence that installation of PWS on asphalt delivery trucks can reduce worker risk to backing construction equipment. More detailed analysis of truck level video, alarm activation, and GPS data are being conducted.

Session: **E1.0**

***Title: Training in Construction***

Moderator: Thomas Bobick

**E1.1**

***Title: Informal Training in Small Construction Work Systems***

Authors: **Smith-Jackson T**, Kleiner B, Artis Sa, Baldev D, Hughes C, Lancaster G

Introduction: Companies with 20 or fewer workers make up a majority of the construction industry, yet few efforts have focused on providing compatible methods to facilitate safety training. Small construction companies comprise a disproportionate number of injuries and fatalities within the construction industry. This study was conducted by the Center for Innovation in Construction Safety and Health (CICSH) to identify ecologically valid training methods for small construction work systems.

Method: This research effort combined qualitative and quantitative approaches to conduct a needs analysis of very small construction companies to identify barriers to and preferences for training. Qualitative methods using interviews and focus groups provided a list of requirements or themes supporting a preference for informal training and barriers to the use of other types of training approaches. Quantitative methods revealed preferences for flexible training methods and a supportive safety climate. Analyses included content analysis, principal components, regression, and heuristic review by external evaluators.

Results: Informal training was found to be the most compatible training approach for these environments. The manner in which the training should be conducted is unique to this work system. We applied a research-to-practice approach developed by the CICSH, which supported development of guidelines and strategies associated with integration of risk perception, work-family dynamics, and situated learning in construction environments were identified.

Discussion: This research identified an informal training approach that is unique to construction environments that meet the following criteria: fewer than 20 workers, workers connected by family/friendship, interference of personal dynamics during the work day, limited time and resources, and poor safety climates. A situated training strategy was identified that was reported by several workers in a number of different ways. Best practices of the situated training strategy were also identified. Future efforts will focus on informal training frameworks.

**E1.2**

***Title: Construction Safety Training Issues for New Construction Employees***

Authors: **Hubbard B**, McGlothlin J, Hubbard S, Mena I, Soendjojo A

Introduction: The construction industry has a large number of work-related deaths, and previous studies suggest that workers may be most vulnerable to construction injuries and fatalities at the beginning of their career in construction, when they have the least experience on the construction site. To minimize the threat to new employees, adequate safety training programs are a necessary part of construction work. This research is a pilot study to identify issues that may affect the impact of safety training on new employees.

Methods: To address the issues associated with safety training programs for new employees, a series of three surveys was conducted with student interns in the construction industry. Students completed surveys (1) prior to OSHA 10-hour safety training, (2) after the OSHA 10-hour safety training and before working on the construction site for their first internship, and (3) after working on the construction site for their first internship.

Results: The results of these surveys indicate both benefits and limitations of existing training. Findings confirm that safety training can play an important role in safety and can familiarize new employees with potential construction hazards. However, one significant limitation of existing safety training is that it requires an understanding of construction terminology that many inexperienced workers do not have. Furthermore, the findings indicate that even workers with



some exposure to construction may not understand terminology associated with construction specialties, such as electrical. The lack of understanding of basic terms used in the OSHA training indicates a significant issue for the trainer and the training process.

Conclusions: This pilot survey suggests that safety training may be enhanced by providing clear definitions and pictorial explanations of construction terminology that may be unfamiliar to new employees. Additional research may provide a better understanding of the issues that affect new employees and how these issues can be addressed through safety training material.

### **E1.3**

#### ***Title: Diffusion of Fall Hazard Safety Training for Hard-to-Reach Residential Construction Workers Through the Internet and Utilizing New Media***

Authors: **Fullen M**, Takacs B, Shambaugh N

Introduction: The numbers of workers in the residential construction industry are on the rise. Falls have continually been the largest contributor to residential construction worker deaths and injuries. These workers are largely self-employed or working for small companies. These individuals are difficult to reach through traditional methods. This research proposed to use the internet to reach this group and engage them in the curriculum development cycle.

Methods: An instructional design research method known as Type I Developmental Research was utilized to study the methodology, product, implementation, and outcomes for this program throughout the design, implementation, and evaluation stages. Two complete cycles of design, implementation, and evaluation cycles have been evaluated. Type I developmental research treats the design-development-evaluation process as a form of inquiry and does so by embedding traditional research methods into the development project and utilizes the case study method (Richey, Klein and Nelson).

The research questions are: (1) Does the training program addressing residential fall hazards and safety bring about individual or group behaviors that may reduce the likelihood of falls from heights on residential construction sites? (2) Does the technology-based availability and delivery of this training material increase trainee interest? (3) Does including residential construction worker, supervisor, and expert feedback into the developmental cycle of training development impact the relevance and acceptability of the residential fall protection training material?

Results: Initial results have shown that the newly developed material has brought about increased knowledge and fall protection usage. The availability of the training material on the internet has led to a broad diffusion and use of the training material, although most seekers of this material were trainers and safety professionals rather than workers. Finally, including workers and others in the training development cycle has impacted the relevance and acceptance of the material.

### **E1.4**

#### ***Design and Preliminary Evaluation of a Fall Protection Curriculum for Apprentice Carpenters in Residential Construction***

Authors: Kaskutas V, **Abraham R**, Dale AM, Lipscomb H, Gaal J, Fuchs M, Evanoff B

Introduction: Results of a comprehensive needs assessment were used to modify the fall prevention curriculum at a carpenter apprenticeship training program.

Methods: We conducted a comprehensive needs assessment via focus groups (n = 36), questionnaires (n = 1,026), and worksite audits (n = 197) to determine gaps in the apprentice carpenters' fall protection training. The current fall prevention curriculum was evaluated and training opportunities identified. We used these data to develop learning objectives, lesson plans, and training methods. After initiating the revised curriculum, we solicited apprentice evaluation and feedback to guide ongoing curricular improvements.

Results: We found that apprentices perform tasks that place them at risk for falls before receiving training. Fall prevention learning objectives (n = 43) were integrated into early apprenticeship training and are reinforced throughout the four-year program. We used adult learning principles to emphasize hands-on experiences and integration of real-life stories. A portion of a framed structure of a residential construction site was fabricated to allow apprentices to observe and practice fall protection behaviors. Preliminary results show that 96% of early term apprentices agree that the residential prop is an effective training tool, and 81% state they will change their

stepladder work habits as a result of training. The training appeared to impact many of the apprentices as evidenced by feedback, such as “I will use these safety tactics daily, I had no knowledge of them before” and “I learned a lot about my own interpretation of risks...risk perception is different than it seems at first.”

Conclusions: Integration of needs assessment results and apprentice feedback was invaluable in revising a fall prevention curriculum. Working closely with the instructors to tailor learning experiences to best meet our learning objectives has provided preliminary positive results. Effectiveness of curriculum changes will be assessed through repeat questionnaires and worksite observations.

Session: **F1.0**

**Title: Injury Prevention in Construction - II**

Moderator: David Fosbroke

**F1.1**

**Title: Applying NIOSH Prevention Through Design to Electrical Hazards in Construction Work Environments**

Authors: **Floyd HL**, Liggett D

Introduction: The construction industry represents 7% of the U.S. workforce, but accounts for 45% of occupational fatalities from electrical hazards. Prevention through Design is an initiative to address workplace hazard mitigation through design. NIOSH launched PtD on the premise that the U.S. is lagging in application of recognized hazard control measures. Engineering solutions that eliminate or reduce exposures are the most effective measures in safeguarding worker safety. ANSI Z10, Occupational Safety and Health Management Systems, provides a hierarchy of hazard control measures. Application of PtD in construction presents a great opportunity for reducing occupational electrical injuries.

Limitations of Existing Methods: NFPA70E, Standard for Electrical Safety in the Workplace, focuses on some control measures, but not those considered most effective in reducing exposure. Use of the most effective control measures is largely voluntary.

Results: Control measures to protect construction workers during installation and demolition are not addressed in a similar manner as maintenance and operating exposures. Some of the barriers include:

- Electrical experts not being familiar with safety management
- Belief that “qualified workers” do not make mistakes
- Designers not being familiar with workplace hazards and safe work practices
- Design firms’ concern that addressing worker safety in the design process will increase liability
- Facility owners not understanding the cost of retrofitting safe work practices and other control measures after design is complete

Discussion: Avenues to better address electrical safety via PtD must be explored. Some opportunities include:

- Working to assure that electrical safety professional participate in the PtD initiative
- Influencing PtD in engineering education
- Developing further proposals to affect revision of existing recognized standards
- Demonstrating support for a new ANSI standard for guiding PtD application
- Working to aid in awareness and education on PtD benefits

**F1.2**

**Title: Construction Safety Training Issues for Hispanic Construction Employees**

Authors: **McGlothlin J**, Hubbard B, Aghazadeh F, Hubbard S, Mena I, Bertot J, Huerta J, Player L

Introduction: Numerous studies indicate that Hispanic construction workers comprise a disproportionately high number of construction workplace fatalities. This research documents the findings of a pilot study exploring issues related to safety training for Hispanic construction workers, which comprise a growing segment of the U.S. construction workforce. This study is a continuation of the research on construction safety training issues for employees new to the construction industry.

**Methods:** A group of Hispanic construction workers in Louisiana was surveyed to determine workers' perceptions of construction safety, levels of safety training, familiarity with construction terms, and population characteristics.

**Results:** The survey found that 58% of the Hispanic workers had not taken any formal training in construction safety. Most Hispanic workers who did have training said that the training was given in Spanish or in both English and Spanish (90%). However, translating the course to Spanish does not address the limitations regarding comprehension of construction terminology. Many Hispanic workers are unfamiliar with the construction terminology used in Occupational Safety and Health Administration (OSHA) 10-hour training. Results indicated that no more than 20% of workers understood any of the terms used, and some terms were understood by only 3% of the workers surveyed. This lack of understanding of construction terminology could diminish the effectiveness of safety training and result in potentially unsafe working practices.

**Conclusions:** This pilot survey implies that safety training for Hispanic construction workers may be enhanced by providing pictorial storybook examples of construction terminologies combined with OSHA 10-hour safety training. Additional research is needed to understand and implement effective safety training strategies for Hispanic construction workers.

### **F1.3**

#### ***Title: A Community-based Participatory Approach to Prevent Falls Among Latino Construction Workers***

**Authors:** Brunette M, Azaroff L, Grullon M, Gagliardi M, Roelofs C, Shepherd S, Latowsky G, Matos C, Anziani D

**Introduction:** Latinos, the fastest growing ethnic group in the United States, are overrepresented in both fatal and nonfatal occupational injuries. The construction sector, with a large share of Latino workers (17%), is also one of the most dangerous industries, accounting for 20% of all occupational deaths. At the same time, falls are the leading cause of death at construction sites. Despite extensive research that has addressed fall prevention in construction, the number of fall-related fatalities continues to rise. In the United States, approximately one of five workers who die from falls on the job is Latino.

**Methods:** Fall prevention interventions shown to be effective in other settings may not be completely appropriate or accessible to the Latino workers. Interdisciplinary, participatory approaches are urgently needed to develop and evaluate measures for protecting the health of immigrant workers. The overall design of this project was based on the well-known framework for Community-based Participatory Research (CBPR) adapted here for occupational safety and health intervention research. This is a cyclical and iterative process involving academic and community partners at each step. The major hypothesis of our project is that CBPR involving city agencies, a labor organization, academia, construction safety experts, workers, contractors, family members, and Lawrence, MA, residents can develop an effective approach to prevent exposure to fall-related hazards affecting Latino construction workers. This initiative also aims to build a community-wide support system to carry on the program in the future.

**Results:** Here we present preliminary qualitative results of the first stage (assessment) of this community-based and community-directed project.

**Conclusions:** By involving employers, health care providers, government agencies, insurance companies, and the broader community with workers and their union, this project is offering the potential for sustainable, systemic change at the multiple levels required for intervention effectiveness.

### **F1.4**

#### ***Title: Reducing Exposure to Pedestrians in Blind Zones***

**Author:** Barclay S

**Introduction:** Reducing runover, backover, and work zone accidents to pedestrians can be done economically and quickly. Being struck by equipment results in some of the most traumatic and expensive accidents at the workplace. The current use of electronic devices, high-visibility equipment, and observers has had little statistical impact on reducing these types of injuries and may even contribute to increased exposure.

Hardhat-mounted mirrors have a potential to reduce this exposure to danger from being struck from behind. In recent years, mirrors have evolved from a safety device for cyclists to ones specifically designed for hardhats and industrial environments.

Methods: Washington State has enacted a law requiring “visual awareness” behind pedestrian workers, specifically those working as flaggers. One method recommended is the use of a mirror mounted to a hardhat. This is also recommended in some NIOSH Fatality Assessment and Control Evaluations.

Hardhat mirrors increase the field of view significantly and allow the wearer to scan, almost instantly, a full 360° with very little effort. This type of safety device could have a quantifiable impact on backover injuries, as the most common denominator to pedestrian injuries involving equipment is the blind zone of the pedestrian.

Results: Most users report that helmet-mounted mirrors require some acclimation but that they would not want to go without one after becoming accustomed to them. This is still a relatively unknown device in industrial safety, so meaningful statistics are still to be proven.

Conclusions: Mirrors are considered an invaluable tool to heavy equipment, mobile machinery, and other vehicles. Hardhat-mounted mirrors add an element of safety to pedestrians that has been proven for decades in other industries. They are economical, commercially available, and address issues in ways not available from any other type of safety device.

Session: **H1.0**

**Title: Using Surveillance Systems to Identify Injury Characteristics in Construction**

Moderator: David Fosbroke

### **H1.1**

**Title: Fatal and Nonfatal Injuries in Construction Industry, 1992–2006**

Authors: **Dong S**, Men R, Fujimoto A

Introduction: The Center for Construction Research and Training (formerly known as the Center to Protect Workers' Rights) has been monitoring construction safety and health to provide a basis for more effectively targeting injury and illness prevention efforts since 1990. This presentation summarizes the trends in fatal and nonfatal work-related injuries among construction workers from 1992 through 2006, the most recent years for which data were available.

Methods: Several large national datasets collected by the U.S. Census Bureau and the Bureau of Labor Statistics were used for this study, including the Census of Fatal Occupational Injuries, Survey of Occupational Injuries and Illnesses, Current Population Survey, and County Business Patterns. SAS version 9 was used for the data analysis.

Results: The construction industry continues to account for a disproportionate share of work-related deaths in the United States even though work-related deaths rates decreased from 1992 to 2006. Rates of nonfatal injuries and illnesses with days away from work declined for the goods-producing industries overall, but rates for construction remained the highest of the four major production industries. Falls are still the number one killer in construction. Being struck by an object, falls to a lower level, and overexertion in lifting continue to be the leading causes of nonfatal injuries. Among construction occupations, construction laborers ranked the highest in number of deaths from injuries. Ironworkers and electrical power line installers had the highest average death rates. During the study period, work-related deaths among Hispanic workers increased dramatically along with the growth of Hispanics in the construction workforce.

Conclusions: Overall, the construction sector continues to face serious challenges with regard to safety and health. Intervention strategies should focus on the leading causes of work-related fatal and nonfatal injuries, as well as vulnerable populations.

### **H1.2**

**Title: Are Back Injuries in Carpenters Decreasing or Not?**

Authors: **Lipscomb H**, Dement J, Kucera K, Silverstein B, Cameron B

Introduction: In light of significant declines over 15 years in work-related back injuries from overexertion and more modest declines in acute traumatic injuries among a large cohort of union carpenters, we explored healthcare utilization for back problems through their private insurance coverage during the same time period.

Methods: Data from workers' compensation (WC) records were linked on an individual basis with records of health care utilization through the union healthcare trust for a dynamic cohort of 18,768 carpenters from 1989–2003. Yearly utilization rates for back disorders, based on months of insurance eligibility, were calculated over the 15 years and compared to patterns of workers' compensation back injuries. Rates of private healthcare utilization were also calculated before and after a work injury adjusting for age and gender.

Results: Sixty percent of the cohort did not seek medical care for back disorders through either WC or their healthcare trust; 10% sought care in both systems. WC claims for overexertion injuries were 62% lower in 2003 than in 1989 while healthcare utilization through the trust for back disorders increased 108%. Private healthcare utilization rates increased among carpenters with more WC injuries (1.3 for one work injury, 1.6 for two, 1.7 for three, 2.2 for four). Utilization patterns through the trust were slightly different for individuals following an acute traumatic work-related injury compared to those with overexertion injuries.

Discussion: The patterns observed raise concern that some work-related care for back disorders could have shifted to the carpenters' healthcare trust, particularly in later years. In any event, the analyses demonstrate interplay across the two healthcare delivery systems in this working population with insurance coverage. Even with the robust data available, these issues are difficult to clearly understand.

### H1.3

#### ***Title: Fractures in Construction: Activities, Events, Sources, and Disability Duration***

Authors: **Courtney T**, Brennan M, Matz S

Introduction: The construction industry continues to experience high rates of disabling injuries (second among major industry groups in 2005). Our earlier work suggested that fractures were among the most disabling injuries in the construction industry. We examined the construction claims experience of a large workers' compensation insurer with national coverage to better understand the activities, events, sources, and disability duration of these fractures.

Methods: We identified 899 fracture cases using ICD-9 and Current Procedural Terminology (CPT) codes, in addition to injury narratives. Disability duration was calculated from indemnity payments data using previously published methods. We analyzed injury event narratives to classify contributing antecedents for fractures. BLS OIICS was used to code antecedent factors. Activities were coded using a version of the BLS CFOI activities coding scheme modified to contain more construction-relevant activities.

Results: The average disability duration for a construction worker with a fracture was 97 days (median = 8 days). The fracture locations with the longest disability durations were the lower leg (median = 68 days), shoulder/upper arm (67 days), and knee (49 days). The most frequent events resulting in fractures were being struck by falling objects (19.7%), struck by slipping handheld objects (11.8%), and falling from a ladder (6.6%). Falling objects were most frequently pipes and ducts, beams, and structural slabs. Hammers, powered drills and jackhammers were the most frequently noted slipping handheld objects. Work on ladders and lifting or loading/unloading materials operations were among the activities in which workers with the longest disability durations were engaged.

Discussion: These findings illustrate the importance of incorporating narrative text analysis and pursuing more granular level assessments of coding in large datasets to better refine our understanding of traumatic injury events such as fractures in construction.

### H1.4

#### ***Title: Relationships Between Medical Care and Paid Lost Time From Work After Work-Related Back Injury Among Washington State Union Carpenters***

Authors: **Kucera KL**, Lipscomb HJ, Silverstein B

Introduction: Back injuries cause significant lost work time in construction. Beyond older age, differentiating those at risk of prolonged lost work time is difficult. We examined relationships between medical care provided for work-related back injuries due to overexertion and time off work among a cohort of carpenters.

Methods: Union records identified a dynamic cohort of 20,642 union carpenters who worked in Washington State from 1989–2003. These data were linked to Department of Labor and

Industries workers' compensation files; data from this state-run program included records of medical care with diagnoses and provider type. Patterns of care received were examined by paid time loss status.

Results: Over 75,000 visits for medical care were identified over 15 years resulting from 2959 back injuries. Chiropractors (37%) and primary care providers (33%) were most frequent first providers followed by specialists (10%) and hospital/ER (9%); number of lost days differed significantly by first provider ( $p < 0.05$ ). Thirty-eight percent of those out 31–90 days and 24% out > 90 days never received physical therapy (PT). Individuals out of work for > 90 days were less likely to see a PT in the 30 days post injury (prevalence ratio = 1.7); mean days to first therapy increased with increasing time away from work (25, 50, and 114 days, respectively, for < 30 days, 30–90 days and > 90 days). Mean number of PT visits in the 30 days after injury was greater among those out longer.

Discussion: Differences in cases based upon treatment in the first month after injury are worthy of further exploration. Although seeing a specialist as first provider was associated with delayed time away from work, being seen in an ER was not. Individuals with prior history of back problems may seek specialist care immediately after injury.

Session: **H4.0**

**Title: Evaluations of Safety and Health Management Practices**

Moderator: Elyce Biddle

### **H4.3**

**Title: Proactive Management: A Multilevel Communication Intervention in the Construction Industry**

Authors: **Moore JT**, Smith A, Cigularov K, Chen P

Introduction: Successful injury-prevention interventions should target all levels of the organization. Interventions focusing on psychosocial variables such as communication can add value to traditional safety programs. The present study describes an intervention targeted at increasing the frequency of safety communication skills across three levels (worker, supervisor, top management) at a general contractor in order to prevent injuries on the job.

Methods: The intervention took place at a general contractor in the Midwest. The first component involved training 24 foremen from five experimental jobsites on leadership communication skills using discussion, role plays, and goal setting. The second component involved meeting with the site-level supervision to explain how to support foreman transfer of training onto the job. The third component was aimed at the tradesman and laborer level of the organization, and involved a communication campaign with posters, safety talks, and paycheck stuffers supporting the importance of safety feedback and sharing near misses in injury and accident prevention.

Results: A pre-intervention assessment of communication climate and employee injuries was collected in October, indicating that the company most needed to improve on sharing near misses and daily verbal exchanges with supervisors. The post-intervention assessment is currently being collected. Pre- and post-training surveys of the foreman workshop indicated that the training changed participants' self-efficacy for giving positive recognition to their crews, and that affective reactions to the training were moderately high. Surveys of the communication campaign indicated that most employees felt the campaign was "very useful" or "somewhat useful" and that the safety talk materials were the workers' favorite component.

Discussion: We hope to see a reduction in injuries reported from the October assessment and an increase in reported frequency of supervisor safety communication skills by workers. Future research should examine the most effective ways to teach safety communication in contractor settings.