



NOIRS 2000

*Pittsburgh, Pennsylvania
October 17-19, 2000*

ABSTRACTS

**National Occupational
Injury Research Symposium**

CDC
CENTERS FOR DISEASE CONTROL
AND PREVENTION

*National Institute for
Occupational Safety and Health*
NIOSH

NOIRS 2000 ABSTRACTS

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NOIRS 2000 ABSTRACTS

Although the abstracts in this publication were proofread to eliminate obvious errors in spelling, punctuation and grammar, they were neither edited nor officially cleared by the National Institute for Occupational Safety and Health (NIOSH). Therefore, NIOSH is not responsible for the content, internal consistency, or editorial quality of the abstracts. That responsibility lies solely with the individual authors. Any use of company names or products throughout this publication does not imply endorsement by NIOSH, the Centers for Disease Control and Prevention, the Public Health Service, or the Department of Health and Human Services.

DAY ONE—TUESDAY, OCTOBER 17, 2000

Session: A1.0

Title: Special Population at Risk: The Aging Workforce

Category: Special Session

Organized by Suzanne Marsh, National Institute for Occupational Safety and Health

Moderator(s): David Wegman

A1.1 The Aging Workforce: Demographic Trends and Factors Affecting the Risk of Injury—Grosch JW

A critical challenge in public health during the next decade is how to insure the safety and health of an aging U.S. workforce. The Bureau of Labor Statistics (BLS) estimates that by 2005, 53 million workers, or 33% of the workforce, will be 45 years or older. Research suggests that older workers are at greater risk for a variety of adverse health outcomes, ranging from musculoskeletal disorders to fatal accidents. This presentation will focus on demographic trends in the U.S. workforce over the next decade, highlighting those occupations and industries that are projected to have the largest number of older workers. In addition, a brief overview will be given of how recent changes in the nature of work may place older workers at greater risk for injury in the future.

A1.2 Occupational Fatalities Among Older Workers in the United States—Marsh SM, Myers JR

Workers 55 years of age and older have been identified as a population at high risk of fatal occupational injuries. This is especially true for the agricultural production industry. The need to understand these high fatality risks for older workers is increasing in importance because of the aging of the U.S. workforce. Data from the Bureau of Labor Statistics (BLS), Census of Fatal Occupational Injuries (CFOI) surveillance system, for the years 1992 through 1997, were analyzed to provide descriptive statistics on all occupational fatalities occurring to workers 55 year of age and older, and statistics specific to the production agriculture industry. Fatality rates were calculated based on employment information from the BLS Current Population Survey (CPS). Between 1992 and 1997, there were 36,932 occupational fatalities identified by CFOI, of which 7,967 (22%) occurred to workers 55 years of age and older, for a fatality rate of 8.8 deaths/100,000 workers. The leading sources of injury for these older worker deaths were: highway vehicles (27%); plant and industrial vehicles (13%); and floors and other working surfaces (12%). The leading events causing these fatalities were: highway transportation (21%); non-highway transportation (13%); and violent acts and assaults (13%). Approximately 25 percent of these deaths occurred in the Agriculture, Forestry, and Fishing industrial division. During the same time period, there were 3,503 deaths in production agriculture, of which 1,823 (52%) occurred to workers 55 years of age and older. The fatality rate for these older production agriculture workers was 46

deaths/100,000 workers. The leading sources of injury for these older production agriculture workers were: tractors (45%); trucks (8%); and agricultural mowers (5%). These data indicate that older workers in general, and older workers in production agriculture specifically, are a key special population to address in future injury prevention efforts.

A1.3 Nonfatal Workplace Injuries to Older Workers: Evidence From the BLS Survey of Occupational Injuries and Illness—Ruser JW

This paper combines three years (1996-98) of BLS data from the Survey of Occupational Injuries and Illnesses (SOII) to describe the workplace injury and illness experience of older workers - those age 55 and older. The paper identifies those occupations by gender that are associated with the highest number of conditions to older workers and indicates the types (e.g., back sprains, fractured ankles) and durations of conditions that they sustain. The distribution of cases by type and duration is compared between older and prime-aged workers (25 to 54 years of age) by gender, to contrast the workplace safety and health experience of these groups of workers.

Because SOII does not collect hours worked for groups of workers, injury rates by worker demographics are not usually calculated. This paper addresses this shortcoming utilizing hours worked estimates from the household-based Current Population Survey (CPS). This paper uses CPS micro data for 1996 to 1998 to generate annual hours worked estimates by detailed occupation and gender for older workers. These denominator data are matched to the SOII case counts to yield workplace injury and illness rates by gender and occupation. The paper shows which occupations are the most risky to older men and women.

A1.4 Injury Rates Among Women and Older Workers in Metal Manufacturing—Cullen MR

As part of an ongoing service relationship with a large, multi-national metals manufacturer, we have merged databases including personnel files, non-workers' comp health claims, industrial hygiene data and a real-time safety data system. By linking these separate data systems, each designed for unrelated purposes, we have been able to investigate the interrelationship between injury rates and severity and an array of possible predictors, including extensive demographic information, information about work and work environment, and location-specific information on work organization. Although this work is at a preliminary stage, evidence suggests a trend towards slightly decreasing injury rates in older workers, but these are unadjusted for injury severity or specific job task. Likewise, injury rates in hourly female workers appear higher than for male counterparts, based on unadjusted preliminary analyses. Methodologic aspects and possible ramifications of early observations will be discussed.

Session: A2.0

Title: **New Directions in Machinery Risk Assessment**

Category: Special Session

Organized by Mike Taubitz, General Motors Corporation and John Etherton, NIOSH

Moderator(s): Mike Taubitz and John Etherton

A2.1 Risk Assessment Developments in the USA—Taubitz MA

This presentation provides a brief look at the history and proliferation of risk assessment in the United States. The US military developed one of the earliest and most pervasive risk assessment approaches contained in MIL-STD-882D. The chemical industry has also been involved for many years. Aviation, medical devices, semi-conductor and robotics industries, along with OSHA have all adopted risk assessment for specific applications.

Even with all of the uncoordinated effort in risk assessment implementation, much is common among the various methods.

Special emphasis will be given to the risk assessment activities coming from the US machine tool industry. In 1995, the Machine Tool Safety Standards Committee commissioned a subcommittee to develop guidelines for risk assessment that could be integrated within the family of ANSI B11 general industry safety standards. The team is nearing completion on a report entitled ANSI B11 Technical Report #3 (TR3) "Risk Assessment - A guideline to estimate, evaluate, and reduce risks associated with machine tools." This methodology improves upon the existing EN 1050 methodology used in Europe because it requires suppliers and users to identify tasks as well as hazards. Identifying task-hazard pairs has been proven to identify more hazards than the traditional approach.

TR3 may well become the benchmark for risk assessment in this country and world because it harmonizes with Europe and builds upon the best, proven methods in use today. The general approach is shown below:

- Task and hazard identification
- Risk estimation
- Risk reduction determination
- Safeguards
- Verification of risk reduction
- Documentation

The presentation notes that there is no one "best" method.

A2.2 Perspectives on International Machinery Risk Assessment—Raafat H

In May '85 the EU Ministers agreed to a New Approach to Technical Harmonisation and Standards to overcome the

problem of trade between partners. The Machinery Safety Directive is one of the Directives and sets out Essential Health and Safety Requirements EHSR's for machinery which must be met before machinery is placed on the market anywhere within the European Community.

EHSR's are expressed in general terms and it is intended that the European Harmonised Standards should fill in the detail so that machinery designers and suppliers have clear guidance on how to achieve conformity with the Directive."

This has fundamentally changed the approach to the prevention machinery accidents in the workplace. In the place of reactive and prescriptive legislation and standards, the EU Directives represent a remarkable breakthrough in risk-based approach to machinery and work equipment safety.

The crucial role of risk assessment in Europe affects both machinery suppliers and users. The European harmonised standards EN 292-1 and EN 1050 outline the role of risk assessment for designers to identify hazards and hazardous events throughout the life cycle of machinery.

A process for incorporating the European machinery safety standards within ISO/IEC is currently underway. The American National Standards Institute (ANSI) is also considering the risk-based approach to machinery safety.

This paper highlights some serious shortcomings with understanding and demonstrating compliance with the EU risk-based approach to machinery safety and draws attention to the benefits of the approach adopted by ANSI-TR3.

A2.3 Risk Management for Machinery-related Injury Prevention—Russell J

In order to perform thorough machinery risk assessments and develop cost effective control options, it is essential to have reliable risk management data. This session will discuss the various types of financial and technical information that should be obtained from various sources before conducting risk assessments.

Specific examples of machine injuries will be discussed, along with types of information that can be provided by various sources such as your insurance carrier, professional safety organizations and governmental agencies. Companies may track direct costs that include medical treatments, compensation benefits and insurance premiums. In some situations, organizations may not be calculating indirect costs such as loss of production, training of substitute employees, machine repairs, accident investigation, etc.

Obtaining and tracking all of these expenses assist in determining priorities for which risk assessments should be conducted, what engineering and administrative controls

should be completed, and calculating potential savings and rates of return on investments. Whether your organization is fully insured or self-insured, this session will cover important issues directly related to the success of your safety program and financial security of the company.

A2.4 Developing Teaching Aids for Machine Risk Reduction with Safeguarding—Roudebush CJ

As the complexity of machine safeguarding increases due to increased reliance on automated manufacturing systems, the need for providing effective teaching aids on understanding and maintaining the desired level of effectiveness for safeguarding also increases. Such teaching aids need to address topics such as: safety related control circuit reliability, integration of different machine safeguarding technologies into a single manufacturing system and proper set-up / use of machine safeguarding technologies. It is the objective of this presentation to provide an overview of the teaching aids and “hands-on” laboratory activities developed for teaching machine safeguarding technologies at the post secondary level.

This presentation will: a) define the objectives of the machine safeguarding teaching aids and curriculum materials, b) provide an overview of how to utilize a programmable logic controller to construct a power press safeguarding simulator, c) explain how electrical relays can be utilized to teach safety related control circuits, d) provide an overview of how to construct a pneumatic energy system lockout simulator to teach machine specific lockout procedures, and e) provide an overview of how to use a digital timing mechanism to teach the concept of light curtain set-back distances.

Session: A3.0

Title: Prevention of Occupationally-acquired Bloodborne Pathogen Infections

Category: Special Session

Organized by the NIOSH HIV Activity

Moderator(s): Janice Huy and Linda Chiarello

A3.1 Using EPINet Surveillance Data to Support Public Policy—Jagger J

The Exposure Prevention Information Network (EPINet) surveillance system tracks occupational sharps injuries and blood exposures in more than 1,000 health care facilities in the U.S. A network of 84 U.S. hospitals have contributed EPINet data to a national research database at the University of Virginia since 1992. These data support prevention initiatives, and have influenced legislation and government agency policy actions. Four examples show how surveillance data have been used: 1) In 1992 the FDA was petitioned to issue a national Safety Alert to advise against the unnecessary use of hypodermic needles for accessing IV ports. The justification for the alert was backed up by

needlestick surveillance data. The Safety Alert was issued in April 1992; 2) In 1998 EPINet and NaSH (CDC) data supported the petition for a government advisory on the hazards of glass microhematocrit tubes. In February 1999 the FDA, OSHA, and NIOSH (CDC) issued a joint Safety Advisory promoting the transition to plastic or plastic-wrapped capillary tubes; 3) California’s law AB 1208, requiring safety engineered sharp medical devices, has challenged by groups seeking exemptions, such as physicians in office-based practices. Their claim that there is no significant risk of sharps injuries in physicians’ outpatient offices was refuted by an analysis of 925 cases of such injuries in the EPINet database. The exemption was denied. 4) Another debate emerged in California. Some groups maintained that the required conversion to safety engineered sharps devices would eliminate the need for sharps disposal containers. An analysis of nearly 1,000 injuries from safety devices in the EPINet database revealed that injuries still occurred during and after disposal, supporting the continuing need for sharps disposal containers.

Other factors contributing to the support of these policy issues will also be discussed.

A3.2 Health Risks in Correctional Health Care Workers: Recent Findings—Gershon R, Mitchell C, Vickers D, Felknor S, Nemhauser J, Trout D, Ballard R, Vlahov D

We are currently completing a two-year epidemiological study designed to characterize the prevalence of occupational exposure to infectious disease in correctional health care workers (CHCWs). Because of the unique characteristics of the correctional healthcare setting, which must balance “custody and care” issues, standard infection control and employee health practices typical of community hospitals may be difficult to achieve. This in turn may present challenges for containing the risk of exposure to infectious agents such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV) and tuberculosis (TB). To better quantify and characterize infectious disease risk, a study was conducted of CHCWs recruited from four different state correctional systems. The following elements were included: Risk assessment questionnaire (e.g., exposure risk factors-community vs. occupational) Serological testing for prevalence of antibodies to HBV and HCV Tuberculin skin test (TST) reactivity HBV vaccination history and current vaccine status.

Preliminary results obtained from over 400 CHCWs are as follows: 10% of CHCWs have evidence of positive HBV serology 16% are TST reactive 3.1% are HCV positive 55 % show evidence of vaccination against HBV.

We are still in the data collection phase, and shortly after that we will begin analyses to determine the risk factors for

infection. At this early stage it is difficult to determine if these rates, which appear to be higher than generally reported for hospital-based healthcare workers, are related to work or community risk factors. Information obtained from the completed analyses will be helpful in developing effective preventive strategies specific for this population of healthcare workers.

A3.3 Improved Compliance with Universal Precautions Among Operating Room and Emergency Department Personnel for Two Years following an Educational Intervention—Kim L, Jeffe D, Evanoff B, Freeman B, Fraser V

We designed and implemented an educational intervention including a hands-on clinical procedure training program aimed at reducing exposures to bloodborne pathogens in the operating room (OR) and emergency department (ED). Participants included OR personnel in cardiothoracic, general, gynecological and orthopedic surgery, and ED personnel at Barnes-Jewish Hospital, a 1,000-bed tertiary care hospital from 6/96 through 8/98. At baseline, and at 1 and 2 yrs. after an educational intervention, observers recorded information about personal protective equipment (PPE), sharps transfers, and blood and body fluid exposures.

In the OR, use of PPE increased significantly at 1 yr. after training and was sustained at 2 yrs. for all specialties and staff subgroups. Observers recorded 597 HCWs during 76 cases at baseline and 783 HCWs during 103 cases at 1 yr. and 502 HCWs during 66 cases at 2 yrs. following education. Use of proper eye protection by HCWs improved from (baseline 322/597 [54%] vs. 1 yr. 516/783 [66%], $p < .001$) and was sustained at 2 yrs. after training (337/502 [67%], $p < .001$). Use of double gloves by HCWs improved from (baseline 97/344 [28%] vs. 1 yr. 250/477 [52%], $p < .001$) and was sustained at 2 yrs. after training (185/311 [60%], $p < .001$). Observed needlestick and body fluid exposure rates decreased from 8.5/100 hrs. at baseline to 4.7/100 hrs. at 1 yr. ($p = .091$) and to 4.0/100 hrs. at 2 yrs., ($p = .068$).

In the ED, staff were more compliant with UP following the educational intervention. Observers recorded 752 HCWs during 88 trauma cases at baseline and 811 HCWs during 119 cases at 1 yr. following education. Full compliance with PPE during trauma resuscitations improved from (baseline 335/752 [45%] vs. 1 yr. 542/811 [67%], $p < .001$). Compliance with PPE by HCWs performing or assisting an invasive procedure improved from (baseline 202/304 [66%] vs. 1 yr. 280/357 [78%], $p < .001$). This educational intervention significantly improved compliance with UP. OR and ED personnel in this study showed an increased use of protective eyewear, double gloves, and experienced fewer occupational exposures.

A3.4 A Community Hospital Intervention Program to Prevent Percutaneous Injury Among Health Care Workers—Doebbeling BN, Beekmann SE, McCoy KD, Ferguson KJ, Woolson RF, Vaughn TE, Torner JC, Grosch JW, Murphy L

Infection control practitioners (ICPs) in all Iowa and Virginia hospitals and Iowa health care workers (HCWs) at risk for blood exposure were surveyed to identify institutional factors associated with standard precautions (SP) adherence and percutaneous injury (PI). Institutional safety climate, particularly job demands and feedback, was related to high SP adherence and PI rates.

A community hospital-based intervention program based on these results was developed emphasizing joint management/employee focus groups, goal setting, training to monitor SP adherence, and provision of feedback. A randomized, controlled trial of institutional-level interventions was implemented using a pre- post-test design. Three community hospitals were randomly assigned to either: 1) unit level (UF), or 2) institutional level feedback (IF). ICPs and co-workers were trained to observe and monitor SP adherence. Feedback was provided monthly via graphical reports.

Follow-up surveys of workers were collected approximately 12 months following the intervention. Outcomes of primary interest include estimation of adherence with specifically recommended SP measures, plans to adhere in the future (Stages of Change), and rates of occupational injury and exposure. The UF hospital had higher proportions of HCWs without blood exposure in prior 3 months at follow-up than IF hospitals (odds ratio [OR] = 1.41, CI95=1.00-1.99, $p = 0.028$), but comparable PI proportions (OR = 0.96, CI95 = 0.89-1.03, $p > 0.20$). In linked pre- and post data, handwashing adherence increased significantly ($p < 0.05$), although there were no significant exposure differences. In HCWs assessed at only one point in all three intervention hospitals, both mean blood exposures (rate difference = -0.73, CI95 = -1.33, -0.13) and PI (rate difference = -0.08, CI95 = -0.16, 0.00) were significantly lower among those assessed at follow-up.

This community hospital-based intervention using goal setting and SP feedback had an important impact on both mucocutaneous and PI exposure. Further study is needed to find the most effective and efficient programs to best protect community HCWs.

Session: A4.0**Title: Monitoring Workplace Health and Safety**

Category: Injury Surveillance

Moderator(s): Stephen McCurdy

A4.1 Evaluating Targeting Strategies to Identify Hazardous Employers—Neuhauser FW, Ellwood J

Federal and State governments have limited resources for intervention at employer work sites meant to improve safety and reduce workplace injuries. Consequently, governments have attempted to target the most hazardous employers where they will have the greatest impact. A number of states also require private insurers to follow similar approaches to identify and intervene with their most hazardous policyholders. These efforts rely on past injury data and/or loss cost data collected by the government or insurers. Both the government and the private insurers have access to different data in type, extent and timing.

The study will evaluate the approaches used by the Federal OSHA and several State Plan states as well as the approaches used by the top 20 insurers in California to determine the effectiveness of approaches in predicting that targeted employers would have been more hazardous in the absence of intervention. Finally, using the experience of a random sample of 20,000 employers over 8 years, the study will define the best approaches to targeting given limitations on the timing and extent of data available to a given targeting entity.

A4.2 Failure of Surveillance Based on OSHA Recordkeeping Rules to Detect Potentially Fatal Incidents Involving Robots—Reeve GR, Rynard SM, Pastula ST, Howe J, Smitt R

OSHA reporting requirements are designed to identify hazardous conditions resulting in injury to workers. However, undetected workplace hazards may exist due to gaps in the OSHA reporting rules. In an analysis of robot-related injuries, surveillance using Ford Motor Company's Occupational Health and Safety System (OHS) data revealed potentially fatal injuries that were unreported due to the fact that they involved no medical treatment beyond first aid.

Ford's OHS system records all work-related injuries at the company's 55 U.S. plant medical departments. From June 1993 through August 1996, the system logged 390,518 First-Time Occupational Visits (FTOVs), of which 200,985 (51%) were reportable to OSHA. By searching patient statements of the incidents for the word "robot," the investigators identified 695 injuries involving robots. A review of cases found that most of the injuries occurred while manually performing work normally done by the robot; working close by the robot; or performing maintenance on the robot. Of the identified injuries, 306 (44%) were OSHA recordable, while 389 cases were not reported under OSHA rules.

Nineteen injuries involved actual contact with the robot: being pinned against a solid object or struck by part of the robot mechanism. Any of these workers could easily have been severely injured or killed, but these incidents did not appear on the OSHA log because only first aid was required for the workers' abrasions or contusions. Consequently, plant supervision was not alerted to these serious hazards.

A4.3 An Eight Year Review of Construction Fatalities Without Accident Prevention Programs—McReynolds MC, Smith HG, Dechert RE, Taheri PA

Objective: To determine how construction fatalities in Michigan correlate with Accident Prevention Program (APP) violations during an 8-year period.

Methods: We reviewed both work-related fatalities and Michigan Occupational Safety and Health Administration (MIOSHA) violations for lack of an adequate APP in Michigan construction from 1991 through 1999. Fatalities from heart attacks, suicides, highway personal motor vehicle trips and aircraft accidents were excluded.

Results: From 1991-1999 there were 204 fatalities reported related to worksite injuries. During the same period MIOSHA issued 106 APP violations associated with those fatalities to individual firms. Regression analysis of fatalities and APP violation was performed. We observed a significant correlation ($r^2=0.58$, $p<0.05$) between the reported APP violations and fatalities.

Conclusion: This data suggests an association between APP violations and fatality rates. The construction sites without APP demonstrated high fatality rates. However further evaluation is needed. All construction employers are required by law to provide APP's. We recommend that the minimal components of a good construction injury prevention program are: a responsible qualified person for coordination of all prevention components including education and emergency response, certified instructors in first aid and CPR, instruction of initial treatment for trauma including an injured employee protocol, a practical injury simulation, an understanding of the concept of the golden hour, and the importance of transferring an injured employee to an appropriate hospital. The design of such programs should include an upper level management commitment, physicians and nurses from trauma centers, and employee representation in the program design. General first aid education must be taught as well as specific injury prevention for the target population. All prevention programs need an increased focus on trauma prevention awareness & initial treatment.

A4.4 The Impact of OSHA Inspections on Injury Rates— Mendeloff JM, Gray W

This paper reports preliminary results of a study of the effects of OSHA inspections on injury rates in manufacturing establishments. The study is based on linking microdata from the BLS Survey of Occupational Injuries and Illnesses with OSHA data on inspections. Earlier studies using these data sets have provided the best available evidence about the effects of OSHA inspections.

This study is able to employ better data than earlier studies. First, we have data from all states, not just the 29 where the enforcement program is operated by federal OSHA. Second, and most importantly, since 1992 BLS has collected detailed information on injuries involving lost workdays. These data include variables on the source of injury, part of body, nature of injury, and event, as well as demographic characteristics of the injured workers.

With these data, we will be able not only to estimate the effect of different kinds of inspections at different kinds of workplaces; but we will also be able to examine the relation between the types of violations cited at workplaces and the changes, if any, in the types of injuries that occur.

As a result, we will be able to assess different theories about the reasons why inspections have effects. Some have proposed a “detection” effect, where injuries decline because OSHA cites and employers abate particular hazards. Others have argued that declines reflect a renewed attention to safety, spurred by the inspection, but only loosely related to the hazards cited. This research has important practical as well as theoretical implications.

A4.5 Fatal Occupational Injuries in a New Development Area in the People’s Republic Of China— Xia Z, Courtney TK, Sorock GS, Zhu J, Fu H, Liang Y, Christiani DC

The labor force of the People’s Republic of China (PRC) is estimated at over 600 million workers making it the world’s largest, single nation labor force. Available estimates of occupational fatal injury counts and rates in China as a whole are uncertain and likely conservative since they have been projected using fatal occupational injury rates from other, similarly developed countries.

Fatal occupational injuries in a new economic development region in Shanghai, east China, are described. All occupational deaths in the East Pujang New Area during the period 1991-1997 were abstracted from multiple, overlapping source documents. There were 426 deaths and a crude mortality rate of 9.1 per 100,000 workers. The death rate was highest in 1995 (14.6) when expansion in the area was most rapid. The construction sector accounted for 55% of the deaths, followed

by manufacturing (23%) and transport, storage and telecommunications (11%). Falls, collisions, struck by/against incidents and electrocutions accounted for 80% of all the deaths. Falls led all other causes of death (39%) and was particularly important in the construction industry (46% of all deaths in construction). The development of ongoing, comprehensive injury surveillance systems in the PRC will be essential to target and evaluate injury prevention activities in the future.

A4.6 Using a Corporate Website to Monitor Health and Safety at a Large Manufacturing Company— Reeve GR

Management leadership is critical to the functioning of health and safety activities at the plant level. To focus and maintain the interest of management it is necessary to routinely evaluate their performance in terms of several different types of metrics. Ford Motor Company has implemented a web-based system to capture and disseminate a comprehensive series of metrics that measure injury/illness rates and the costs associated with all medically related absences. This website is updated monthly for the 60 manufacturing locations in the U.S. It contains Lost Time Case Rates and Severity Rates for all injuries and illnesses as well as rates for cumulative trauma disorders. Department-level injury/illness rates are included. The website also presents data for medical absences, workers compensation costs, non-occupational disability costs, the number of persons on medical leave for occupational and non-occupational disorders, and the number of workers at work with medical restrictions.

The monthly data for each plant is displayed in a unique set of bar chart graphics and pareto charts that allow quick visual assessment of where the plant stands with all other plants of the same manufacturing type. A series of quadrant charts display the ranking of each plant in each manufacturing division in terms of their aggregate injury/illness rates for the last six months and whether the six-month trend is improving or worsening.

Since this system was launched in mid-1999, its metrics have been the corporate standard for formally evaluating Plant Managers’ performance in reducing injuries and illnesses and the associated absences. This website also eliminates cumbersome manual data compilations from several different systems which reduces the potential for data errors or manipulation.

Session: A5.0**Title: Farms and Adolescents**

Category: Intervention and Evaluation

Moderator(s): Dennis J. Murphy

A5.1 Evaluation of a National Rural Youth Safety Initiative—Lee BC, Westaby JD, Berg RL, Kiu L

In 1997 the National FFA implemented its Partners for a Safer Community initiative, aimed at promoting agricultural safety and health among youth through education, community development and youth leadership at 4,000 FFA chapters across the U.S. With funding from NIOSH, a comprehensive evaluation was conducted to assess the program's impact on students' knowledge, attitudes, practices, and leadership skills, as well as development of community partnerships. Using a randomized controlled trial design, 110 FFA chapters in ten rural states were randomly assigned to a Standard intervention (Partners...as implemented nationwide), an Enhanced intervention (included Standard intervention plus mail/phone contacts, additional resources and financial incentive to motivate safety training interactions between FFA chapters and community nurses) or a Control group. Data from FFA Advisors and students were collected pre- and post intervention using a 70-item questionnaire with scales for self-esteem, safety knowledge, safety consciousness, risk taking, and leadership (all scales had internal consistency > .75). Self-generated identification codes matched students' and Advisors' responses in the beginning and end of an academic year. Data from Enhanced group community nurses were collected per telephone interviews.

Pre-intervention data were collected from 8,068 students (68% = male; 42% farm residents, 83% FFA members, 84% were 17 years or younger) and post-intervention data from 5,926 students. Of these, 3,081 were matched individuals. Using ANOVA and ANCOVA analytic procedures, data of matched individuals revealed minimal difference between experimental and control groups, thus, limited impact of the Partners...program. Even with a financial incentive for collaboration, 37% of community nurses (n=30) reported no contact, 57% reported spending five or fewer hours and only 5% nurses reported spending six to ten hours interacting with the FFA Chapter. Of ten factors affecting Partners... implementation, FFA Advisors reported "extremely busy with various school responsibilities" most strongly.

A5.2 Etiology and Consequences of Injuries Among Children in Farm Households: Regional Rural Injury Study-II—Gerberich SG, Gibson RW, French LR, Masten A, Renier C, Church TR, Luan X, Shutske J, Carr WP

While there is some evidence about the magnitude of agricultural-related fatality among children, there is limited information about morbidity and the risk factors for both morbidity and mortality. This effort addresses both etiology

and consequences of agricultural injury in the five state region of Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska. Following a pilot study to test the methods and data collection instruments, lists of farm operations for each state maintained by the United States Department of Agriculture, were sampled randomly to select farms for participation in the project. The research design employs an eligible cohort of 4,000+ farm households, including children less than or equal to 19 years of age and involves unique methods for collecting data, simultaneously, for both risk factors and incidence/consequences of agricultural injuries.

A brief participation interview established eligibility for the study (i.e., actively involved in farming/ranching, as of January 01, 1999, and if the household included children); and to determine willingness to participate in the full study, involving two subsequent comprehensive interviews to collect data for two six month periods. A specially designed Computer Assisted Telephone Interview (CATI) instrument, administered by trained interviewers, included: 1) Household Log—basic demographic information; 2) Injury Log— injury occurrences (January 1- June 30 and July 1- December 31) and consequences; and 3) Exposure Section— exposures to potential risk factors on the farming/ranching operation for cases and randomly selected controls (3:1) <19 years of age.

In addition to descriptive analyses, logistic regression is used to model the dependence of injury on each exposure of interest and corresponding confounders. The ability to identify the risk factors, incidence rates, and consequences of injury is critical for providing sound scientific data for the development of focused intervention efforts.

A5.3 Farm Work Injuries to Children on Kentucky Beef Cattle Farms—Browning SR, Westneat SC, Szeluga R

Injury surveillance efforts in Kentucky have identified farming operations with beef cattle as associated with an increased injury risk to workers compared to other commodity farms. Examining the risk of farm-related injury among children, particularly on farms with beef cattle, is pertinent in Kentucky because its 71,000 family-owned farms use child labor to a greater degree than other states.

We report baseline results from a three-year longitudinal cohort study of children aged 5-18 years working on family farms in Kentucky. The primary intent of the study is to characterize the work tasks and exposures of these children— an estimated 41% of whom live on beef cattle farms—and to investigate a diverse set of potential risk factors for their work-related injuries. Parental or guardian proxies of a cohort of children (N= 450) are being interviewed every six months regarding the work exposures of the children and injury events which lead to a loss of time from farm work or school. Detailed data collection efforts regarding farm management practices on family farms are also being implemented.

Preliminary data indicate that adolescent males age 16-18 years had the highest rate of farm work injuries (9.2 injured children per 100 per year). Machinery, animals, contact with inanimate objects, and falls were the primary external causes of nonfatal farm work injuries among children age 5-18 years. Beef cattle farms with an annual farm income of more than \$10,000 per year reported 70% of children age 10-18 work half or more days per year on the farm.

Our data suggest that rates of farm work injuries among adolescent males working on family farms may be higher than other states. At the meeting, further results related to the ongoing injury surveillance and assessment of children's agricultural work exposures will be presented.

A5.4 Case-Control and Case-Crossover Studies of Agriculture Related Injuries to Children and Adolescents—Alexander BH, Keifer MC, Rivara FP

Agriculture related injuries are a recognized occupational and paraoccupational health problem for children living and working in rural areas.

Case-control or case-cross over study designs are appropriate methods for studying the determinants of agriculture related injury in children and adolescents. However, several considerations must be made in the design and conduct of such studies to account for the nature of these injuries and the population understudy. Using examples from an on-going study of childhood injuries in Washington state, the problems of case ascertainment, control selection, and relevant exposure assessment are presented.

Case identification requires multiple information sources to locate cases in a region and adequately describe the injuries. Coding schemes are not reliable for identifying agricultural injuries so clinic and hospital records must be manually searched. The specificity of these records will vary considerably.

Controls must represent the agricultural exposure experience of the population that gave rise to the cases. This constraint poses several methodological and logistical problems when identifying the control population. The seasonal nature of agriculture makes the exposure window critical when assessing risk factors for injury. The exposure assessment must also account for variation in baseline environmental and behavioral risk factors across subsets of injured and non-injured children

The use of a case-crossover study design eliminates the problem of valid selection of controls and is potentially useful for examining transient risk factors. However, the identification of appropriate hazard periods and assessing exposure within those periods is problematic.

The study of etiologic factors of agriculture related injury to children and adolescents is required to further develop effective prevention programs. The case-control and case-crossover study designs are appropriate if investigators are mindful of the potential limitations.

This work is supported by Grant Number 1R01/CCR516767-07 from the U.S. National Institute for Occupational Safety and Health.

Session: A6.0

Title: Economics

Category: Social/Economic Impacts

Moderator(s): Thomas W. Camm

A6.1 Common Performance Measures for Canada's Occupational Safety and Health Agencies—Warrack BJ

While governments are continuously monitoring their financial performance, they are also looking at new ways to assess the effectiveness of the regulatory frameworks in which they operate. For many years, a variety of output measures have been used by occupational safety and health (OSH) agencies in Canada as a surrogate for non-existent outcome measures, i.e. the counting and reporting of numbers of activities such as inspections, investigations and the like. More recently, Canadian jurisdictions have looked at other types of program efficiency and effectiveness measures.

The concept of assessing performance in OSH agencies has many dimensions, from measuring client service to measuring the impact of effectiveness of safety regulatory performance across industry sectors. OSH performance has long been measured in many differing ways across jurisdictions. There is some similarity in the types of measures being used, but in the past, there has not existed a national system of comparative safety and health indicators.

This paper will outline some cooperative work that has been undertaken at a national level in Canada to develop such a series of indicators. A national system of performance measures will enable OSH regulators to identify areas of common shortcoming, allowing them to develop co-operative safety activities at the national level to target areas of common concern. Standardised measures would assess and benchmark national safety and health system performance. These measures would also allow for the benchmarking of performance across jurisdictions.

This presentation will look at the work that has been taking place to develop this national system for the measurement of safety and health performance for Canada's safety and health regulatory agencies and will discuss some of the problems of common data collection, coding systems etc. that affect the development of national performance measurement systems.

A6.2 Earnings Loss From Occupational Injury: A Comparison of Six States—Biddle J, Boden L, Reville RT, Imbens G

This presentation reports results to date in the second year of a three-year study of the consequences for workers of workplace injuries (funded by NIOSH, California and New Mexico). We estimate the earnings losses associated with workplace injuries using data from six states: California, Washington, Oregon, Wisconsin, Florida and New Mexico. In each state, we have longitudinal data on earnings before and after injury for a large sample of injured workers. Using identical methods for each state, we estimate losses and also calculate the fraction of losses replaced by workers' compensation benefits. We also compare estimates using several alternative methods. In this presentation, we will report the earnings loss and wage replacement estimates for each of the six states. We will also outline our hypotheses about the causes of differences across states, to be investigated during the final year of the study.

A6.3 Cost Effectiveness Methodologies Used to Evaluate the Impact of an Intervention Reducing Injuries in Fire Service—Fabricant RA, Johnson L, Beaton R

Nationwide 43.1% of U.S. firefighters sustained line-of-duty injuries in 1997 (IAFF, 1997). In that same year, these on-the-job injuries resulted in 6,285 lost work hours per 100 firefighters. Furthermore, in 1997 nearly one-quarter (23.7%) of all firefighter retirements were due to line-of-duty injury "early" retirements. The purpose of this paper is to describe methods used to estimate the actual economic costs of line-of-duty injuries in the fire service and the potential cost-effectiveness of interventions or programs intended to reduce the incidence of such duty-related injuries using a single urban fire department as a case exemplar.

Methods: Departmental on-the-job injury and absenteeism data from a single large metropolitan fire department were available for a three year pre-intervention baseline as well as for the initial year following the implementation of a multi-component leadership intervention. These objective departmental data included the type of injury sustained, a brief description of their injuries, as well as the locale and shift on which they occurred. From this documentation, all injuries were categorized and coded using the ICD-9, and a magnitude estimate of the severity was assigned to each injury by a trained coder.

Findings: Using a range of both direct and indirect costs, along with reasonable assumptions and decision-rules, the fiscal and economic impact of duty-related injuries in an urban fire department were calculated for a three year baseline. These costs to the Fire Department and to their public sector funding agencies need to be considered in evaluating the potential benefits of an intervention (also with fixed costs) which

reduces on-the-job injuries in the fire service. The strengths and weaknesses of these cost effectiveness methods and related models will be considered.

A6.4 The Incidence and Costs of Acute Injuries From a Validated Injury Surveillance System at a U.S. Manufacturing Company—Fogleman M, Reeve G, Rynard S

In allocating resources for the prevention of occupational injuries and illnesses, it is important to realize the impact of acute injuries and the associated costs. The purpose of this project was to determine acute injury rates from a validated occupational safety and health data system and to compare the occupational acute rates and costs with those for cumulative trauma disorders. All first time occupational visits (FTOVs) for 55 manufacturing facilities in a U.S. company were reviewed for the calendar year 1998. This review focused on the occupational injury and illness experiences of more than 100,000 hourly employees.

Metrics included in the analysis were the FTOV rate, the OSHA case rate, the number of cases that resulted in days away from work, the total number of days away from work, and estimated costs associated with days away from work. These metrics (other than costs) were standardized to rates expressed as units per 200,000 hours worked. The results indicated that acute trauma accounted for 68% of all FTOVs with a rate of 73.5 for acute versus 33.5 for cumulative trauma. The OSHA case rate and the lost day case rate were similar for both acute injuries and cumulative trauma. Acute injuries accounted for 43% of all days away from work with a rate of 73.4 days away per 200,000 hours worked. This implies that there should be renewed attention to the issue of acute injuries.

A6.5 Where is it Safest to Work: Ranking States by Occupational Injury and Illness Costs Per Capita—Waeherer GM, Miller TR, Leigh JP, Sheppard M

This paper ranks states by per capita cost of occupational injury/illness and by severity of nonfatal days away from work (DAFW) cases. It uses 1993 Census of Fatal Occupational Injuries and Bureau of Labor Statistics DAFW survey data. For each victim, we modeled medical payments, the dollar value of wage and household work losses, and the dollar amount that an informed jury would award to compensate pain, suffering, and lost quality of life if a trial were appropriate and the victim's negligence did not contribute to the injury/illness. Analyses of national and state health care data sets yielded spending per victim by diagnosis (illness or nature of injury and body part injured). The work loss analysis modeled the duration of work-related disability for victims who had not returned to work by BLS report data and accounted for permanent disability. Wage losses were modeled with Current Population Survey data. The jury verdict analysis examined almost 2,000 occupational injury verdicts (typically awards against third parties) and adjusted for bias in who decides to sue.

The most dangerous states to work (those with the highest occupational injury and illness costs per capita), are Alaska (highest), West Virginia, and Wyoming. The safest “states” to work are the District of Columbia (lowest), New Hampshire, and Massachusetts. These ranks account for event frequency and severity but not for state medical care price differentials or earnings differences for comparable jobs. Ranking by cost per DAFW case (i.e., by severity), in order, West Virginia, New Jersey, Texas, the District of Columbia, and Wyoming rank highest. New Hampshire, Florida, Hawaii, Idaho, and South Dakota rank lowest. Climate and the nature of available jobs bound health and safety levels. Controllable factors — employer attitudes toward worker protection, reporting enforcement, government occupational safety and health efforts — also are influential.

A6.6 Years of Potential Life Lost in the National Traumatic Occupational Fatality Database—Gilbert SJ, Bailer AJ, Stayner LT

Years of potential life lost (YPLL) may be a more meaningful and intuitive measure of the impact of occupational fatalities than traditional measure such as SMRs and rate ratios. We examine the YPLL for different industries, occupations, and causes of death over the years 1980 to 1995 using the National Traumatic Occupational Fatality Database (NTOF). The number of deaths, total YPLL, and average YPLL are calculated for different combinations of industry, occupation, and cause of death. The industries of Public Administration, Mining, and Construction have the highest average YPLL per death among those classified, with Public Administration and Mining losing a potential of at least 39 years per fatal injury. Construction makes the largest contribution to the total YPLL accounting for over 18 percent of the total YPLL for all industries. We also compare YPLLs over time for other causes of death such as suicide, motor vehicles, falls, and those struck by falling objects. A comparison of YPLL by cause of death may help target intervention strategies designed to prevent occupational fatal injuries in different industries.

Session: B1.0

Title: Special Populations at Risk: Who are They? What are Their Injury Research Needs?

Category: Special Session

Organized by the NORA Special Populations at Risk Team

Moderator(s): Sherry Baron

Organizer: Dawn Castillo

B1.1 Special Populations at Risk: Who are They? What are Their Injury Research Needs?—Frumkin H

Occupational hazards are known to be distributed differently. Workers with specific biologic, social, and/or economic characteristics may sustain increased risks of work-related diseases and injuries. This discussion will identify various

such special working populations. These include populations defined by age (both young workers and old workers); by ethnicity, educational attainment, or geographic location; by socioeconomic status; by gender; by disability status or by a disease or genetic predisposition; or by some combination of these. Some special populations seem to be defined by purely biological attributes, and others by social categories, but in nearly every case social policies and practices are superimposed on biological features to define populations as “special”; in this sense. Recognizing special populations is worthwhile for at least three reasons. First, since special populations may sustain increased risks, recognizing them identifies opportunities for high-yield interventions. Second, since specific approaches may be required by special populations, recognizing and better understanding them permits the design and delivery of more appropriate services. Third, since special populations have in some cases suffered employment discrimination, including being underserved by occupational health programs, recognizing them permits more just and equitable service delivery.

B1.2 Work Injuries and Age: Is the News all Bad?—Wegman DH

Broad reviews of age and injuries at work suggest that injury frequency decreases while injury severity and fatal occupational injuries increase with age. Reduced injury frequency with age probably relates to job experience and familiarity with tasks, but increased severity (generally measured as time-off-job) is less easily explained. Greater injury severity could result from aging of the neurologic and musculoskeletal systems, but other possibilities include that older workers may be less likely to report minor accidents or be advised to take more time before returning to work. More specifically, injury type and source are reported to vary by age with back injuries higher in older workers and eye/hand injuries higher in younger workers. Agents of injury also differ by age, for example, hand tools are a more common cause in younger workers and working surfaces are a more important cause in older workers. Studies of injury experience within occupations reveal a less clear pattern in part because both age-related injury risk and employment vary by specific job. When jobs are classified according to the relative importance of physical capacity and experience requirements, age-related injury risk patterns can be seen. Jobs “enhanced” by age show a negative relationship between injury and age while those “impaired” by age show a positive relationship. Longitudinal studies of worker and workplace characteristics suggest that when work teams accommodate age of workers better injury experience results. Other studies provide indirect evidence for the importance of organizational factors showing job dissatisfaction positively related to disability retirements and good supervisor support negatively associated. The presentation will review published evidence on age-related work injury risk and make recommendations for further study

to better understand and guide prevention efforts for these risks.

B1.3 Injury and Employment Patterns Among Hispanic Construction Workers—Hunting KL, Anderson JTL, Welch LS

Medical record data were analyzed to compare injury patterns among 3,290 injured Hispanic, black, and white construction workers treated at the George Washington University emergency department from 1990 to 1998. Initially, we observed that Hispanics had a higher proportion of serious injuries and hospitalizations than blacks and whites. However, injured Hispanic workers were disproportionately employed as laborers and in other less-skilled trades.

Construction tasks and injury risk factors vary considerably between trades. Since trade and ethnicity are strongly linked, any evaluation of ethnicity's role in work-related injury must therefore try to separate the risk associated with trade. Laborers and carpenters had enough injuries for within-trade comparison of injured whites, blacks, and Hispanics. Differences between ethnic groups in diagnoses, circumstances, hospitalization, and recommended time off and light duty largely disappeared after controlling for trade.

Interviews conducted several weeks post-injury indicated that a smaller proportion of injured Hispanic workers belonged to a union and reported that anything could have been done to prevent their injury, as compared to black and white workers. Interviews conducted one year post-injury revealed that a larger proportion of injured Hispanic workers took time off work and that the duration of the time off was three to four times longer than for other injured workers. Also, the physical, financial, and emotional consequences were more apparent one year later for injured Hispanics, even after controlling for trade.

These observations suggest that minority status is a predictor of trade, and trade is a predictor of injury risk. Once injured, Hispanic workers may be disadvantaged in terms of health and employment options; further research is needed to explain these findings. In addition to reducing injury hazards, interventions should address the limited employment, union membership, and training options that are available to minority workers.

B1.4 Workers With Disabilities—Pransky GS, Blanck P

Individuals with disabilities constitute a sizeable portion of the workforce and represent the majority of working-age persons who are unable to work. Historically, barriers to employment have included attitudinal discrimination by employers, lack of workplace accommodations, and inadequate job training. The disability rights movement has achieved considerable success in promoting legislation to

remove these barriers and uphold equal employment. Research suggests that many employers actively attempt to incorporate persons with disabilities into the workforce and gain substantial economic benefit from their participation, without incurring burdensome expenses. Occupational health providers are asked by employers and others to provide input on feasibility and safety, a difficult task given the lack of scientific study on the occupational abilities and risks associated with specific disabilities. The limited amount of data available suggests that an excess risk for persons with disabilities cannot be predicted with any degree of certainty for most jobs. Thus, more research is needed to understand the actual nature and magnitude of risks due to disabilities, effectiveness and costs of accommodations, and persistence of discrimination.

Session: B2.0

Title: New Developments With ROPS for Tractors

Category: Special Session

Organized by Dennis Murphy, Penn State University and John Etherton, NIOSH

Moderator(s): Dennis Murphy and John Etherton

B2.1 Policy Toward Increasing ROPS Use—Myers ML

The Great Plains Center for Agricultural Health convened a National Tractor Risk Abatement and Control: The Policy Conference in 1997. Forty participants at this conference agreed on 25 action items to reduce tractor-related injuries that account for about 270 deaths annually. If these action items are implemented, 2,000 lives could be saved by 2015. Twelve of these action items relate to the policy question, "How do we assure that every tractor that needs a ROPS, has one?" The action items include the development of an educational/social-marketing program to change social norms regarding ROPS and monitoring and regularly publishing tractor injuries. They also include establishing a tax rebate or subsidy program for retrofit ROPS installation, promoting the development of incentive programs such as certified safe farms, and finding ways to limit liability risks for ROPS manufacturers, dealers, and installers. The participants agreed that a research program needs to be established to design ROPS for pre-ROPS tractors and for work environments with low clearances. The participants also agreed that starting in 2003 but before 2015, that a sequence of public actions were needed in the following order: that all tractors have a ROPS if operated by persons under the age of 18 years, all tractors sold must be equipped with an approved ROPS, a recycling/removal program for tractors not appropriate a ROPS retrofit, all tractors operated on public roads have an approved ROPS, ROPS be installed on all tractors for which approved ROPS are available, and all tractors be equipped with approved ROPS.

B2.2 Probability of Death During a Farm Tractor Overturn—Cole HP, McKnight RH, Reed DB, Browning SR, Struttmann TW, Piercy LR

Objective

Estimates of probability of operator death from all types of overturns range from .40 to .75 per event for farm tractors not protected by Rollover Protective Structures (ROPS). Because the total number of tractor overturns (the denominator) for a given population of farmers for a given time period is unknown these estimated fatality probabilities may be inaccurate. This study estimated the probability of death during a tractor overturn by using (a) tractor overturn fatality surveillance data, (b) surveillance data of farmers' non-fatal tractor overturns, and (c) Census of Agriculture farm population data. Method A state-wide death certificate analysis for the 1982-92 period found 164 Kentucky farmers died in tractor overturns (14.9 deaths/year). A second study monitored all farm fatalities during the 1994-98 period and found 71 farmers died in tractor overturns (14.2 deaths/year). A third study sampled 998 farmers from 60 Kentucky counties and found that 1 in 9 age 55-years or older reported having overturned a tractor in their lifetime. One-third of this group survived two or more overturns. Data from these three studies and Census of Agriculture data for were used to estimate the total number of tractor overturn events (the denominator) for Kentucky farmers for a 20-year period.

Results

We estimated the denominator as 2,680 farm tractor overturns during the 1982 to 2002 year period. Assuming 14-tractor overturn deaths/year, the estimated numerator is 280 fatalities. The probability of death during a tractor overturn is .104, much smaller than previous estimates. These estimates apply to Kentucky farm tractors not protected by ROPS and seat belts and pooled across all types of overturns, tractors, and operators.

Conclusion

Accurate estimates of the probability of death are important for credibility of intervention programs that promote ROPS and seat belts, and for cost-analysis and cost-effectiveness studies of these programs.

B2.3 Performance of the NIOSH AutoROPS—Powers JR, Harris JR, Snyder KA, Ronaghi M, Etherton JR, Newbraugh BH

Approximately 132 agricultural tractor overturn fatalities occur per year (Myers and Snyder, 1993). The use of rollover protective structures (ROPS), along with seat belts, is the best known method for preventing these fatalities. One impediment to ROPS use, however, is low clearance situations, such as orchards and animal confinement buildings.

To address the need for ROPS that are easily adapted to low clearance situations, the Division of Safety Research, National Institute for Occupational Safety and Health, developed an automatically deploying, telescoping ROPS (AutoROPS). The NIOSH AutoROPS consists of two subsystems. The first is a retractable ROPS that is normally latched in its lowered position for day-to-day use. The second subsystem is a sensor that monitors the operating angle of the tractor. If a rollover condition is detected by the sensor, the retracted ROPS will deploy and lock in the full upright position before ground contact.

Static load testing and field upset tests of the NIOSH AutoROPS have been conducted in accordance with SAE standard J2194. Additionally, timed trials of the AutoROPS deployment mechanism were completed. The design of the retractable ROPS and sensor, as well as the results of the different testing phases will be discussed.

B2.4 Analyzing the Effectiveness of Composite Materials for an Automatically Deployable ROPS Application—Glaessgen EH, Raju IS, Ronaghi M, Etherton JR

Composite materials are used extensively in the aerospace community because of their structural characteristics such as high stiffness and strength-to-weight ratios. However, laminated composites are difficult and expensive to manufacture and often exhibit low resistance to impact, notches and other forms of damage. These deficiencies prevented the use of composites in critical or primary structure. Recently, the development of textile-based composites has significantly increased the damage tolerance characteristics of the material while improving manufacturability and reducing cost.

As cost, manufacturability and damage tolerance have improved, composites are being applied to automotive, infrastructure and other non-aerospace applications. The National Institute for Occupational Safety and Health (NIOSH) is conducting research to develop an automatically deployable roll over protection system (AutoROPS) for use on farm equipment. The AutoROPS system is designed to work in applications where overhead clearance limits the use of a fixed roll over protection system (ROPS). In the AutoROPS application, a lightweight and damage tolerant ROPS structure is critical for rapid deployment from the stowed configuration and for reduction of the weight of the deployment system while maintaining the integrity of the structure during roll-over. Composite materials offer the potential to satisfy this requirement.

In this presentation, recent advancements related to composite materials are briefly reviewed and important considerations for the application of composite materials to the AutoROPS are discussed including the cost, manufacturability and performance of composites under the

ROPS loading regime. The response of composites under compression loading, their energy absorption limits in cantilever loading, and durability enhancements with newer textile materials also will be presented.

Session: B3.0

Title: Advancing Research in the Area of Social and Economic Consequences

Category: Special Session

Organized by the NORA Social and Economic Consequences Team

Moderator(s): Elyce Biddle

B3.1 Research Needs and Priorities for Determining the Social and Economic Consequences of Occupational Illness and Injury—Boden, LI

Relative to other areas of occupational health and safety research, research on the social and economic consequences of occupational illness and injury is a newly emergent area with many opportunities for significant impact. This presentation reviews the strides made by recent research and discusses priority areas for additional research.

Recent studies have provided new understanding in several areas:

1. Low filing rates of workers' compensation claims for both chronic and acute illnesses and injuries, implying that a substantial undercount exists.
2. Measuring the out-of-pocket costs of workplace illnesses.
3. Determining that workers' compensation benefit payments cover only a small fraction of workers' out-of-pocket costs.
4. Specifying the considerable range of non-economic costs as a consequence of workplace injuries and illnesses incurred by workers and their families. These costs include problems maintaining their roles as spouses and parents, as well as anger and depression.
5. Initial determination of the most important factors in improving return-to-work outcomes.

Based on these research results, The NORA Social and Economic Consequences Team has developed research needs and priorities, with significant input from a 1999 conference. These include studies that:

1. Develop national estimates of occupational illness and injury impacts and track trends,
2. Estimate impacts on special worker populations.
3. Evaluate impacts on workers and their families.
4. Estimate non-workers' compensation injury and illness costs of firms and evaluation of current practices of firms in accounting for OSH investments and the costs of work hazards, injury and illness.
5. Develop and validate standardized instruments for collecting information on social and economic costs from employers and workers.
6. Evaluate the impacts of interventions on production costs.

7. Evaluate the impacts of interventions designed to improve return to work.

8. Develop accounting systems for unions and managers to measure the benefits and costs of reducing workplace hazards.

B3.2 Estimating the Social Burden of Occupational Illness and Injury in the United States—Amick B, Christiani D, Katz J

This paper presents a general approach for conceptualizing the social burden of injuries that focuses on the importance of social participation. Because of the diversity in the United States, a challenge in conceptualizing the social burden is to develop a framework which is generalizable to apply to the many types of workers and work situations, yet specific enough to allow operationalization of constructs.

Social participation in valued roles such as work, family, leisure and civic provides one way of beginning to develop a broad framework for understanding the social burden of occupational illness and injury. We illustrate the operationalization of these roles by introducing a new class of health outcome measures, generic role specific functioning measures. In particular we present new measures for measures of household and leisure time functioning and work limitations. Then we illustrate how these measures can be used to assess the social burden of occupational illness and injury. Finally, we consider the social burden of work-related disability on labor market participation and economic activity illustrating the important role of occupational health services in reducing the social burden.

B3.3 Creating an International Data Repository for Workers' Compensation Research—Beletz J, Cathey M

The International Association of Industrial Accident Boards and Commissions (IAIABC) was formed in 1914 for the purpose of advancing standardized best practices in workers' compensation. After working 85 years on designing data collection systems and uniform statistical measures, the association has formed strategic alliances with stakeholders to begin a program of systematic and reliable collection of statistical data from workers' compensation administrations. This work is being conducted jointly with The Center for Workers' Compensation Studies, established to supplement the IAIABC committee research work and meet their educational and scientific research efforts.

To develop the data repository, the IAIABC sought innovative ideas and sound judgement for structuring the international data repository. As a result, a contract was awarded to provide technology, data warehouse, and consulting services in support of the repository. The vendor is providing a comprehensive range of customization, statistical and analytical tools to support rapid, low-risk and

low-cost construction of IAIABC-specific claims. In addition, the vendor is providing coverage decision support applications including indemnity, medical, legal and associated claims costs.

The state-of-the-art decision support and data warehousing capability is based on an advanced claim, coverage, and workers' compensation data reporting system. The initial phase for the international data repository will include data from Release 1 First Report of Injury and IAIABC Core Data Elements for the calendar year 2000 and should consist of at least five (5) jurisdictional participation.

This system has the capability to integrate administrative, financial, and clinical information both within and across lines of business, administrative jurisdictions, industries, and risk. The modular technology in the repository will make it possible for both rapid and incremental deployment catering to the current and future needs of those interested in workers' compensation issues, such as public policy research for preventing and managing work injury and illness.

B3.4 A Report on the Third International Conference on Measuring the Burden of Injury—Luchter S, MacKenzie EJ

INTRODUCTION

A major issue in measuring injury outcomes is the applicability of methods and indices, originally developed for measuring the outcomes from medical treatment of disease, to the measurement of outcome from injury. The third in a series of international conferences on this issue was held in May, 2000 at which experts in injury outcomes from around the world gathered to discuss methods for measuring the burden of injury and hearing the results of recent research from their colleagues. The theme of the conference was "Towards Consensus."

METHOD

Invited speakers made presentations covering health profiles and indices, preference based and quality of life measures, coding and classification of non-fatal injuries, and new developments in cost of injury. Keynote presentations included health status and quality of life measures, rehabilitation measures, and cost/effectiveness cost/benefit issues. Poster presentations covered research results related to quality of life and economic methods of measuring injury burden. Breakout sessions and open discussion periods focused on the theme issue of developing consensus on methods that could be applied by the international injury outcome research community. The views on injury outcome as seen by the World Health Organization were presented at the conference dinner.

RESULTS

A summary of the presentations and the poster abstracts are included in a proceedings published shortly after the

conference. In addition to summaries of the presentations and posters the proceedings includes a discussion of the level of consensus reached and identification of issues that need additional research.

CONCLUSIONS

Considerable progress was made in identifying areas where additional research is needed in order to work towards consensus on methods of measuring injury burden. Preliminary plans were made for a follow-on conference to be held in 2002 in Canada.

Session: B4.0

Title: Injuries in the Construction Industry I

Category: Injury Surveillance

Moderator(s): Matt Gillen

B4.1 Deaths and Injuries Caused by Falls Through Roof and Floor Openings and Surfaces, Including Skylights—Bobick TG

Occupational injuries and fatalities caused by falling is a serious problem throughout the U.S. Analyses of data from the Census of Fatal Occupational Injuries prepared by the Bureau of Labor Statistics (BLS) indicate that during the 7-year period, 1992 through 1998, a total of 4,507 workers died as a result of a fall. Of these, 3,964 (88%) involved a fall to a lower level. An important sub-set of the "falls to a lower level" category involves workers falling through an existing opening in the floor or roof, or through floor or roof surfaces, including skylight fixtures already installed. During this 7-year period, 447 workers lost their lives by falling through something - 136 deaths occurred when workers fell through an existing roof or floor surface, 198 workers died by falling through existing openings (e.g., openings created for stairs, elevators, or skylights), and 113 died when they fell through already-installed skylight fixtures.

In addition to fatalities, numerous injuries result from these "fall-through" events. Because of the circumstances associated with these incidents, the resulting injuries are among the most severe cases, in terms of median number of "days away from work" (DAFW). Analyses of other BLS data (i.e., Survey of Occupational Injuries and Illnesses) indicate that 16,251 injuries occurred during the 6-year period, 1992 through 1997 (latest available data). The total DAFW related to these injuries was calculated to be 259,258. Data analyses revealed that the median number of DAFW (across all six years) were 13, 12, 43, 19, and 33 for falls through (a) existing floor openings, (b) floor surfaces, (c) existing roof openings, (d) roof surfaces, and (e) skylights, respectively. These analyses highlight the significance of falls through work surfaces, and suggest the need for injury reduction through modifying current work practices and developing appropriate engineering controls.

B4.2 The 1990'S : Claims Management Versus Injury Management—Alberg NM

Over the past decade, Canada has generally seen a downward trend in occupational injury rates, as tracked by claims filed with the provincial Workers' Compensation Boards (WCB). Prior to this time, many provincial Compensation Boards were faced with large unfunded liabilities which threatened their capacity for long range planning. In the province of Manitoba, Canada, the frequency of timeloss injury claims has seen a 25% reduction from the 1990 rate of 42.9 per 1000 workers, to 34 per 1000 in 1998. During the same period, the severity of Manitoba timeloss injury, as measured by the average days lost per claim, has declined from a period high of 18.1 days in 1991 to 14.8 days in 1998.

Although the 1990's displayed this downward trend, a review of Manitoba's rates over the past two decades shows two plateaus separated by a substantial fall in timeloss rates in the early 1990's. The 1990's saw many local initiatives both in occupational safety and health and in the administration of the Compensation system. Each initiative of injury prevention, early return and modified work routines, compensation pay-outs, experience rating, among others, has had some impact on subsequent profiles of injury claims.

A 10 year review of trends in Manitoba WCB injury claims, using both timeloss and no timeloss or medical aid claims, suggests some achievements in primary prevention of injury, intermingled with other impacts of claims management strategies. This latest multiplicity of intervening factors requires a variety of approaches to defining "risk" when analyzing WCB data. The new dilemma for safety and health professionals is how to interpret and use the information presented by WCB claims data in the 21st century. How best can we determine which parts of the changing injury rates reflect true primary prevention of injury at the workplace?

B4.3 Struck-by Injuries to Construction Workers—Welch LS, Hunting KL

Struck-by injuries are a leading cause of fatal and non-fatal injuries in the construction industry, yet much work is still needed to understand the nature of this diverse group of injuries. Using a data set of 3390 injured construction workers treated at the George Washington University Emergency Department in Washington, DC, we looked at the injuries to workers who were struck by an object. To identify these injuries we examined injuries in which the circumstance was E-coded as stuck-by, struck against, caught, or cut, or where the injury involved a machine, an explosion, or a vehicle. To focus on those injuries where a worker was stuck by an object that was not under his control, we then removed injuries that were due to being caught between two objects, or where the worker was moving and hit himself on an object. There were 747 stuck-by injuries in this sub-set.

We will describe in detail the nature and circumstances of these injuries. For example, we found that laborers were more likely to be involved in a "struck-by" injury (40% vs. 29% for all workers combined). The injured worker was most frequently struck by a metal object (14% of all struck-by injuries), a pipe (8%), a board (7%), a beam (6%), a power tool (5%), and a scaffold (4%). A struck-by injury resulted more frequently in a contusion, a head injury or a fracture than did other causes of injury.

We will present more detail on these injury patterns and discuss opportunities for prevention of struck-by injuries. This group of struck-by injuries differs from those that would be defined by E-codes or BLS groupings alone; the implications of this will be discussed, and results compared to an analysis based on the BLS classification.

B4.4 Occupational Fatalities in the U.S. Highway Construction Industry, 1992-1997—Pratt SG

Highway construction workers (Standard Industrial Classification [SIC] 1611) risk injury from varied exposures: traffic vehicles, construction equipment, electric current, falls, and collapsing materials. Data from Census of Fatal Occupational Injuries research files for 1992-1997 were used to characterize these fatalities by event, source, employer class, and person type.

Of the 708 fatalities during 1992-1997, construction laborers (252, 35.6%) and truck drivers (91, 12.9%) together accounted for nearly half. Five hundred (70.6%) worked for private contractors, 110 (15.5%) for local government, and 98 (13.8%) for state government. Major injury sources were trucks (285, 40.3%), construction machines (127, 17.9%), and cars (84, 11.9%).

Three distinct event types were identified: contractor vehicle events inside work areas (288, 40.7%); traffic vehicles entering work areas (159, 22.5%); and other traffic crashes, without mention of a work area (135, 19.1%). The remainder were other events, including electrocutions, falls, and trench collapses (126, 17.8%). Trucks contributed substantially to traffic vehicle events inside work areas (46.5%), other traffic crashes (68.2%), and contractor vehicle events (41.0%). Traffic vehicles entering work areas were 45.0% of state government fatalities, compared with 20.6% for private contractors and 10.9% for local government.

Data were analyzed by person type for 582 fatalities with a vehicle or machine as the injury source; 57.0% were workers on foot, 35.1% were operators, and 7.9% were passengers. Workers on foot were involved in high proportions of traffic vehicle events inside work areas (93.1%) and contractor vehicle events (60.1%). Among other traffic crashes, operator fatalities predominated (77.8%).

This research identified fatality types within SIC 1611 and differences by injury source, employer class, and person type. Emphasis on risks from traffic vehicles entering the work area and contractor vehicles should continue; however, other traffic crashes and non-vehicular events (37% of fatalities) should also be addressed by employer safety programs.

B4.5 In-depth Analyses of Falls From Heights in the Construction Industry—Kines PA

Numerous epidemiological studies have been carried out on accidents in the construction industry, and a majority of them conclude that there is a need for more details surrounding the contributory factors. This study deals with the investigation and analysis of the complex interrelationships between technical, psychosocial and organisational risk factors involved in serious and fatal accidents in the construction industry. The study involves the use of retrospective quantitative and qualitative analyses of conventional injury reports and statistics, as well as prospective in-depth investigations and analyses. The in-depth methodology will include detailed interviews of victims, colleagues, foremen, managers etc. to investigate the processes that lead up to events immediately preceding the injury, and to study their sequential and spatial relationships. The purpose of this study is to develop a method for uncovering comprehensive knowledge regarding the antecedents of occupational injuries, and to analyse the potential of this knowledge in contributing concise information for use in effective accident prevention.

Session: B5.0

Title: Work Organization

Category: Intervention Evaluation

Organized by the NORA Organization of Work Team

Moderator(s): Steven Sauter and Jane Lipscomb

B5.1 A Longitudinal Study of Workplace Organizational Factors and Injury Rates—Gilbert JW, Shannon HS

The current research follows up and expands previous work which compared, cross-sectionally, organizational aspects of firms with their workers' compensation lost time frequency rates (LTFR). The unit of analysis was the workplace. Specific areas investigated were organizational structure and philosophy, organizational philosophy on occupational health and safety, the role of labor markets and unions, the internal responsibility system, perceived risk and physical conditions, and financial performance and profitability. Data on these areas were captured via a survey of management and labor at each workplace and related to LTFR.

Among the factors found to be related to lower LTFR in the initial research were: concrete demonstration by management of commitment to safety; greater involvement of workers in

general decision making; greater willingness of the joint health and safety committee to solve problems internally; and greater experience of the workforce.

At the time of writing, data have been obtained on the subsequent LTFR for these workforces, a follow up of 10 years. Analysis is beginning to answer several questions:

- 1) Were there important changes or trends in LTFR over the 10 years of follow-up at these workplaces?
- 2) Were there significant changes or trends in non-lost-time injury rates?
- 3) Was there a significant change in the severity of injuries reported over the follow-up period by workplace, initial injury rate, or by type of industry?
- 4) Was there an important change in the types of injuries reported over the follow-up period by workplace, initial injury rate, or by type of industry?
- 5) Did the workplace characteristics at the start of follow-up period predict the subsequent patterns of LTFR?

Results of the analyses will be presented at the symposium. A brief discussion of the initial and current research will be given and conclusions presented.

B5.2 When am I My Brother's Keeper? Defining Others' Safety and Well-Being as In-Role Versus Extra-Role Behavior—Hofmann DA, Morgeson FP

Extra-role behaviors, or organizational citizenship behaviors, have been well researched within the organizational sciences. Essentially, these behaviors constitute actions that are not formally prescribed, but which individuals perform in order to help the organization be more effective. In this study, we focused on safety-related citizenship behaviors; namely, safety-related behaviors that deal with helping others within a work team perform more safely. Examples of these behaviors included voicing concern for others' safety-related performance, suggesting improvements in organizational procedures to make them more safe, coaching fellow team members that safety violations will not be tolerated, etc.

The primary focus of the study was an investigation of when employees perceive these safety-related citizenship behaviors to be part of their formal job responsibilities (i.e., in-role) versus above and beyond the call of duty (i.e., extra-role). The results indicated that organizational (e.g., organizational justice), leadership climate (e.g., leader-subordinate relations, leader openness), team (e.g., effective working relationships among team members), and safety climate factors (e.g., management commitment to safety) were associated with defining these behaviors as more in-role. Furthermore, employees that rated these behaviors as more in-role were more likely to engage in these behaviors. The implications for building a safe and learning oriented culture are discussed.

B5.3 Work Organization and Health: The CAW/McMaster Benchmarking Project—Lewchuk WA, Robertson D

Research over the last ten years has placed work organization on a par with exposure to dangerous substances and exposure to biomechanical risks in understanding work related health outcomes. Building on the pioneering work of Karasek & Theorell (1990) studies have linked work organization with hypertension, musculoskeletal injuries, migraines, and psychological distress (Wilkins & Beaudet 1998). Lewchuk & Robertson 1996&1997 have been particularly concerned with the impact of lean production on the health of workers. This paper will present results from two ongoing projects that further this research.

One project is using the original survey instrument developed in 1996 and 1997 in plants in the United States, Britain, Japan and Mexico. The number of surveys in the data base exceeds 10,000 from more than thirty different workplaces. Analysis of this data provides an international profile of working conditions as well as insights into the relationship between the elements of lean production and health and safety conditions. Here the focus is on work loads, control, relations with management and levels of stress and exposure to ergonomic risks.

A second project is revisiting the Canadian workplaces originally surveyed in 1996 and 1997. It involves a psychosocial job characteristics survey plus casual and ambulatory blood pressure readings from a large sample of employees drawn from up to 20 different workplaces in the automobile sector. We will explore whether the health risks revealed by our “subjective” psychosocial job characteristics survey data are consistent with the health risks revealed by our “objective” biological data. We will search for correlations between different work organization characteristics and “subjective” and “objective” measures of health risks. Finally, we will examine health risk profiles of different workplaces and how they are correlated with work organization characteristics.

B5.4 Unintended Consequences: Organizational Practices and Their Impact on Health and Safety—Kaminski MA

Managers often implement new organizational practices in order to improve firm performance, while neglecting possible side effects. Using data from 84 small manufacturing firms, this study examines the relationship between 6 organizational practices and both productivity and injury rates. The organizational practices include four human resource (HR) management practices and two organizational design factors.

The first HR practice, performance-based pay, compensates employees not just on the number of hours worked (wages) but also on some measure of productivity or performance. Performance-based pay is associated with significantly higher

lost time injury rates, but contrary to expectations, with lower productivity. The second HR practice, the use of temporary employees, was marginally related to higher injury rates and unrelated to productivity. Third, the use of overtime was associated with lower productivity, but contrary to predictions, was also significantly associated with lower injury rates. The fourth HR practice had the most positive results: the number of hours of training was associated with lower lost time injuries and higher productivity.

Two organizational design factors were also considered. Teams were marginally associated with lower lost time injury rates, but were unrelated to productivity in this sample. The use of a production line was significantly associated with higher injuries, consistent with other work.

While managers may implement these various organizational practices in search of higher performance, only one of these factors—training—yielded these results. However, the choice of practices potentially have an impact on workers’ health. Performance-based pay, the use of temporary employees, and the use of a production line were all associated with higher injury rates. In contrast, training, teams, and overtime were associated with lower injury rates. The paper also discusses the potential interaction between hazard controls and organizational practices.

B5.5 Organizational Factors and Return to Work Following Lost-Time Injury—Cole DC, Brooker AS, Clarke JC

Return to work (RTW) programs have rarely been formally evaluated. We present two complementary studies, a jurisdiction-wide prospective prognostic cohort and a cross-employer qualitative study. At the time, experience-rating of employers’ premiums was only partially implemented. Workers’ Compensation (WC) legislation stipulated that employers of ≥ 20 employees were required to re-employ injured workers, who were able to perform the essential duties of their pre-injury employment, and to adapt the work or the workplace for the worker as needed, provided no undue hardship to the employer resulted.

The cohort was a random sample of WC claimants with a work-related soft-tissue injury who completed a baseline interview within 21 days of their accident date ($n=1833$). During this interview and the follow-up year, injured workers were asked about workplace offers of arrangements to help them return to work. Only a minority (36%) received such offers, more commonly from larger employers in particular sectors. Offers were unrelated to workers’ pain levels. Most arrangements consisted of temporary modifications such as reduced (24%) or flexible (25%) work hours or a lighter job (57%), rather than more permanent changes to layout or equipment (8%) or job design. Offers of arrangements were associated with reduced WC temporary total benefit duration.

In the qualitative study, 17 persons from workplaces with RTW programs were interviewed. Sessions were tape recorded, the tapes transcribed and coded based for 'barriers to' and 'facilitators of' successful RTW. Workplace factors affecting RTW included the origins, composition and management of RTW programs, physical factors related to work and the production process, communication within the workplace and the overall organizational climate. Throughout, careful consideration of the collective agreement and full involvement of labor in the creation, coordination and problem-solving of the RTW program were regarded as important.

Session: C1.0

Title: Childhood Agricultural Injury Prevention

Category: Special Session

Organized by David Hard, National Institute for Occupational Safety and Health

Moderator(s): David Hard

C1.1 Overview of the NIOSH Childhood Agricultural Injury Prevention Initiative—Hard DL, Castillo DN, Myers JR, Pizatella TJ, Olenchock SA

In 1996 the report *Children in Agriculture: Opportunities for Safety and Health—A National Action Plan* was released by the National Committee for Childhood Agricultural Injury Prevention. The National Action Plan (NAP) generated "specific, targeted recommendations for research, education, policy, and evaluation, with the goal of reducing unintentional agricultural injuries to children younger than 18 years." The plan specifically recommended that NIOSH assume leadership for coordinating efforts to implement this action plan at the federal level. Due in large part to the awareness and concern raised by this report about the childhood agricultural injury issue, NIOSH received a congressional appropriation of \$5 million in fiscal year (FY) 1997 and through the present year for implementing this Initiative.

The NIOSH Childhood Agricultural Injury Prevention Initiative builds upon previous NIOSH research and objectives, as well as recommended action steps in the NAP. In implementing the Childhood Agricultural Injury Prevention Initiative, NIOSH has assumed a leadership role by identifying, funding and developing quality childhood agricultural injury prevention activities. Due to efforts by NIOSH and its extramural partners, progress is being achieved. Thirteen extramural research proposals specific to childhood agricultural safety and health research have been completed and new grants were solicited in FY 2000 to conduct additional research in this area. A national surveillance plan for childhood agricultural injuries is being developed and implemented by NIOSH. An extramural partner has also developed a model for training professionals in childhood agricultural injury prevention approaches. Finally, the important issue of being able to turn research findings into

action and serve as a resource for injury professionals working with this specific target population is addressed by another extramural partner, the National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS), located at the Marshfield Medical Research and Education Foundation in Marshfield, Wisconsin.

C1.2 NIOSH Approach to Childhood Agricultural Injury Surveillance—Myers JR

NIOSH began the Childhood Agricultural Injury Prevention initiative in the fall of 1997 to implement the recommendations developed by the National Committee for Childhood Agricultural Injury Prevention (NCCAIP). One NCCAIP recommendation is for surveillance specific to childhood agricultural injuries. A major issue for childhood farm injuries is the number of special populations (e.g., youth workers, minority children, youth visiting farms). Because of these special populations, no single surveillance method provides adequate information for all youth. NIOSH is evaluating different surveillance approaches for these special populations. Farm operator surveys are proposed for the surveillance of youth living on, or visiting farms, and youth directly hired by the farmer. A general farm operator survey has been completed, and a second survey targeting minority farmers is planned. A personal interview survey is ongoing to assess injuries to young minority farm workers, and the children of minority farm workers. A national hospital emergency department surveillance system is also being evaluated for assessing youth farm injuries. The Census of Fatal Occupational Injuries and death certificates will be used to assess fatal injuries. These methods will be used by NIOSH to develop an ongoing periodic surveillance approach for childhood agricultural injuries.

C1.3 Agricultural Disability Awareness and Risk Education (AgDARE)—Reed DB, Kidd PS, Rayens MK, Westneat SC

Introduction: Adolescent farm workers continue to be at high risk for work-related injury and death. An agricultural safety curriculum using narrative and physical simulations was developed and tested in this three year NIOSH sponsored intervention project.

Method: Using a quasi-experimental crossover design, 22 high schools in Kentucky, Iowa, and Mississippi were assigned to a treatment or control group. All enlisted agriculture students (n=1,127) completed surveys that included questions about farm residency, farm work, and occupational exposures to machinery, noise, and dust. Each student received pre and post tests on safety attitude and safety behavior. The treatment schools received two days of class instruction using the developed curriculum. Instruction was delivered by the research team at two separate times of

the school year. Control schools received no intervention. A select number of students who completed the treatment are participating in farm safety audits to observe the students' work habits (results forthcoming).

Results: Of the full sample, 861 reported working on farms. Of these, 74% were male and 76% were in the ninth or tenth grade. Only 53% had ever driven a ROPS equipped tractor, 4.9% had overturned a tractor, and 42% had used PTO powered equipment with missing or damaged shields. 72% worked in dusty environments; 85% in noisy surroundings. There were significant differences ($p < .05$) in safety attitude and safety behaviors between the treatment group and control groups. There were no significant differences between order of treatment (narrative or physical) and control groups on the dependent variables.

Conclusions: Farm youth continue to be at risk for serious injury. Adolescents' safety attitudes and behaviors can be influenced by an interactive school curriculum that requires little class time. Formal evaluation of the curriculum needs to be conducted to assess the real utility of this project in the classroom.

CI.4 Health Professional Education to Promote Use of Childhood Agricultural Injury Prevention Guidelines— Shutske JM, Schermann M

A one-hour educational module was developed in cooperation with the National Children's Center for Rural and Agricultural Health and Safety. This module was designed to educate parents, other care providers, and health professionals about the appropriate use and application of the North American Guidelines for Children's Agricultural Tasks. Initial pilot surveys of a small group of central Minnesota workshop participants ($n=12$) early in the year 2000 showed a significant change before and after the workshop in attitudes related to the age at which participants believed it was appropriate for children in their county to perform five different farm tasks. These tasks were: operating a tractor and towed tillage implement ($p=.003$); hitching a towed implement to a tractor ($p=.002$); operating a combine ($p=.006$); feeding milk to calves ($p=.007$); and operating a PTO-driven stationary machine ($p=.008$). The mean increase in appropriate age, according to participants before and after the workshop, ranged from +1.46 to +2.30 years for the various tasks. Additional results will be reported that will include a larger group of health professionals from Minnesota, Wisconsin, North Dakota, South Dakota, and Iowa. In addition, a continuing education credit-bearing website for nurses is being developed and will be summarized.

CI.5 National Children's Center for Rural and Agricultural Health and Safety— Lee BC

In 1997 the National Children's Center for Rural and Agricultural Health and Safety was formally established with

a mission to enhance the health and safety of all children exposed to hazards associated with agricultural work and rural environments. The Center is based at the Marshfield Clinic, Marshfield, WI, one of the largest rural healthcare facilities in the U.S. with over 550 physicians. Funding is provided by the National Institute for Occupational Safety and Health (NIOSH), federal Maternal and Child Health Bureau, Marshfield Clinic, and private donations. Staff members have advanced training in injury prevention, health promotion, agricultural safety, and related topics. The team works in cooperation with nine formal collaborating agencies that enable the Center and collaborators to maximize their capacity to address complex issues related to children and agricultural injury prevention. A 23-member external Steering Committee guides the Center's program planning. The Center's work is based on objectives and recommendations of the 1996 National Action Plan for Childhood Agricultural Injury Prevention.

Major activities of the Center include: a) provide technical assistance for childhood agricultural injury prevention programs; b) convene consensus development sessions to address controversial issues; c) enhance communications between researchers, safety specialists, and the farming community; and d) provide professional training, including an annual Rural Youth Safety Summer Seminar. A recent accomplishment was the development and dissemination of the North American Guidelines for Children's Agricultural Tasks. Currently, a major initiative is underway to address the occupational health and safety needs of migrant farmworker youth.

The Center's primary audience is professionals involved in agricultural safety and health. An Internet site provides ready access to injury facts, prevention program tactics, and links to relevant web-sites for rapid referrals. A toll-free phone line (888-924-7233) provides opportunities to access staff for in-depth technical assistance inquiries.

Session: C2.0

Title: Prevention of Deaths and Injuries Among Fire Fighters

Category: Special Session

Organized by the NIOSH Fire Fighter Fatality Investigation and Prevention Program

Moderator(s): Richard Braddee

C2.1 Firefighter Fatality Statistics for 1999—Fahy RF

Since 1977, the National Fire Protection Association (NFPA) has collected data annually on all on-duty firefighter fatalities in the U.S. This presentation will provide an overview of fatalities over the past 23 years, focusing on the deaths in 1999. Topics to be covered include the types of duty during which the fatalities occurred, the cause and nature of the fatal injuries, the ages of the victims, and details on fireground fatalities.

Over the past two decades, we have found that there are two major problem areas that together account for the majority of firefighter deaths — heart attacks and motor vehicle crashes. Examination of available medical data has consistently shown that four out of every five firefighters who died of heart attacks had had prior heart attacks, bypass surgery and/or severe, detectable levels of arteriosclerotic heart disease. When looking at the motor vehicle crashes, we find that the majority of victims are volunteer firefighters, a large share of whom were responding to emergencies in their own vehicles.

And finally, the trends over the past 20 years will be reviewed, highlighting the types of injuries that have virtually disappeared as protective equipment and training have improved but also looking at less encouraging trends in fatality rates per million structure fires over a span of time when the number of structure fires has been declining.

C2.2 Fire Fatality Investigations: The NIOSH and IAFF Programs—Duffy RM

When a fire fighter makes the ultimate sacrifice, we usually say that he or she died in the line of duty. The fact of the matter is that fire fighters don't die peacefully in the line of duty, they are killed—often abruptly and violently. All too often, the investigations into a fire fighter's death were incomplete, inaccurate, or inconclusive. In those cases, we never able to find out what, if anything went wrong. Rarely did anyone take responsibility for a fire fighter's death.

It has been the position of the 235,000 members of the International Association of Fire Fighters that fire fighter's death must receive a thorough and unbiased investigation. After extensive lobbying by the IAFF, President Clinton, in 1998, directed the National Institute for Occupational Health and Safety (NIOSH) to investigate all line-of-duty fire fighter fatalities. Since the inception of this program, the NIOSH Fire Fighter Fatality Investigation and Prevention Program has detected several significant hazards to fire fighters and has made a significant change in protecting the health and safety of our members.

Whether the fault for the loss lies with inadequate resources and staffing, poor incident command, bad communications, lack of training, equipment failure, or human error—NIOSH and the IAFF are committed to uncovering the truth.

C2.3 Overview of Program from a Volunteer Perspective—Schafer H

The National Volunteer Fire Council (NVFC) participated in a workshop to determine the level of detail, content and distribution of the National Institute of Occupational Safety and Health's (NIOSH) Fire Firefighter Fatality Investigation and Prevention Program.

The purpose of the program is to determine factors that cause or contribute to firefighter deaths suffered in the line of duty. The outcome of the reports are distributed in many ways including mailings to the major fire service organizations and postings on the NIOSH website.

The reports are beneficial to the volunteer fire service for a variety of reasons. These include prevention of firefighter death and injury. The NVFC has used the informative reports to educate the volunteer fire service through its newsletter and website. Oftentimes, the recommendations made require additional funding for equipment, training, etc. The NVFC educates members of Congress through the reports as well.

Most recently, a report identified that if firefighters involved in a wildland fire had had more equipment, lives may have been saved. This type of equipment is made available to volunteer firefighters through the Volunteer Fire Assistance program. This program is woefully underfunded and receives \$24 million in annual requests when less than \$3 million is awarded. If proper funding were in place, firefighters lives may be saved.

C2.4 NIOSH Fire Fighter Fatality Investigation and Prevention Program—Braddee R

The United States currently depends on approximately 1.2 million fire fighters (about 210,000 career/paid and 1 million volunteers) to protect its citizens and property from losses caused by fire. The National Fire Protection Association and the U.S. Fire Administration estimate that on average, 105 fire fighters die on the job each year (1986-1995 data), and in 1995 alone, 95,000 fire fighters were injured at work.

In Fiscal Year 1998 Congress allocated funds to the National Institute for Occupational Safety and Health (NIOSH) to address the continuing national problem of occupational fire fighter fatalities and injuries. The objectives of this effort by NIOSH include the investigation of all occupational fire fighter fatalities to assess and characterize the circumstances surrounding these events for the purpose of developing, evaluating and disseminating prevention recommendations to fire fighters and fire departments across the country. The investigations are conducted to gather information on factors that may have contributed to the traumatic occupational fatality. For each case investigated, data are collected on factors associated with the agent (mode of energy exchange), the host (the fire fighter who died) and the environment. These factors are identified during the pre-event, event, and post-event phases. These contributory factors are investigated in detail in each incident, and are summarized in the investigation report, along with recommendations for preventing future incidents.

The national initiative by NIOSH to prevent fire fighter fatalities and injuries will result in substantial new information which will be of importance to fire fighters, fire departments, State fire marshals, researchers, and others interested in the protection of fire fighters. It is imperative that this and existing information are readily accessible to those who can intervene in the workplace and use it for the development of recommendations and guidelines to prevent fire fighter injuries and deaths.

C2.5 Hazards and Fires Involving Oxygen Regulators—
Washenitz FC

Over the past 5 years, there have been over 16 reports of aluminum regulators used with oxygen cylinders burning or exploding. These incidents caused severe burns to over 11 emergency medical service providers, health care workers, and patients. Many of the incidents occurred during emergency medical use or during routine equipment checks. The NIOSH Fire Fighter Fatality Investigation and Prevention Program has investigated 3 incidents concerning fire fighters who had been severely burned by oxygen regulator fires. In the course of these investigations, NIOSH sought outside expertise in and outside the federal government, and learned of previous cases. Evidence suggests that aluminum in these regulators was a major factor in both the ignition and severity of the fires, although there were likely other contributing factors. Recommendations to minimize the occurrence of future incidents were made in reports summarizing these investigations. Additionally, NIOSH and the FDA jointly released a Public Health Advisory alerting fire departments, safety officers, biomedical engineers, nursing homes, emergency transportation services, rescue squads, state EMS systems, hospital administrators, home health care agencies, and risk managers of the hazards that may exist with aluminum regulators. NIOSH is currently involved in a project with the National Aeronautics and Space Administration (NASA) to develop a positive ignition test. The test is being developed and proposed to the American Society for Testing Materials as a possible standard, which would require that all regulators be tested before distribution to consumers. A training video is also being developed by the FDA and NIOSH concerning the hazards involved with oxygen systems. The video will demonstrate the safe handling of oxygen systems and will be disseminated to emergency medical service and health care providers.

C2.6 Oxygen Regulators Testing and Standards—
Stoltzfus J

Investigation of recent medical oxygen regulator fires indicates that promoted ignition of vulnerable regulators has occurred with increasing frequency, resulting in catastrophic burnout and injury to equipment operators. In February 1999, the National Institute for Occupational Safety and Health

and the Food and Drug Administration issued a joint public health advisory regarding explosions and fires in oxygen regulators used in medical and emergency applications. In response, the ASTM Committee G-4, along with several oxygen equipment manufacturers, is developing a standard entitled, “*Standard Test Method for Evaluating the Ignition Sensitivity and Fault Tolerance of Oxygen Regulators Used for Medical and Emergency Applications.*” The intent of this provisional standard is to develop a test method that will fairly evaluate the ignition sensitivity and fault tolerance of oxygen regulators used in medical and emergency applications.

The most recent draft of the standard was sent to the Committee G-4 Test Methods subcommittee for ballot in July. The results of the ballot will be discussed at the Fall 2000 committee meeting in Paris, France in September. It is hoped that agreement can be reached regarding all the important issues related to the standard so that it can be released as a provisional standard after the September meeting. The standard is being treated as a provisional standard. This status will allow the test method to be developed and validated so that it can be upgraded to a full consensus standard as soon as possible. Meanwhile, manufacturers who need a tool to evaluate new regulator designs can use the test method.

The standard provides an evaluation tool for determining the fault tolerance of oxygen regulators. A fault tolerant regulator is defined as 1) having a low probability of ignition as evaluated by rapid pressurization testing and 2) having a low consequence of ignition as evaluated by forced ignition testing. The rapid pressurization test is performed according to International Standards Organization 10524, Section 11.8.1, which is similar to Compressed Gas Association E-4. In this test, the regulator is repeatedly subjected to rapid pressurization with oxygen. The heat from the compression of gas in the regulator is the ignition source. The method determines the resistance to ignition by the pressure surge that occurs each time the upstream valve is opened.

The consequence of ignition is evaluated by burning an ignition pill at the inlet of the regulator. The ignition pill, which is designed to simulate the burning of possible contaminants or components that are typically found in medical and emergency oxygen systems, is ignited by the heat of compression from the same system used in the rapid pressurization test. A regulator is considered fault tolerant when consumption of the ignition pill has occurred without external breach of any pressurized regulator component or ejection of molten or burning metal or ejection of any internal parts from the regulator.

Session: C3.0

Title: Applications of the Case-Crossover Design in Occupational Injury Research

Category: Special Session

Organized by Gary Sorock, Liberty Mutual Research Center for Safety and Health

Moderator(s): Gary Sorock

C3.1 Overview of Case-crossover Methods for Injury Research—Mittleman MA, Sorock GS, Lombardi DA

In applying the case-crossover design in injury research, one of the major challenges is in identifying the person-time at risk of the specific injury under study. This key element sets observational injury research apart from the study of most chronic conditions and acute illnesses. For example, unlike myocardial infarction that can occur at any time, an occupational injury requires special circumstances to occur. Thus, only a subset of an individual's person-time ought to be considered eligible for study. In fact, if this is not taken into account, effect estimates can be biased in any direction.

A second major challenge in applying this technique in the injury field is that exposure information is often not available prospectively. This is not an inherent feature of the design, but rather a fact that arises because even the most common injuries are still relatively rare, making prospective data collection uneconomical in many settings. Furthermore, there are only limited circumstances where preexisting records collected for administrative or other purposes are available for ad hoc studies. As a result, many studies must rely on retrospective patient self-report for exposures that may be etiologically relevant.

Finally, a third major challenge in conducting these studies is in identifying control periods that are at once similar to the time at which the injury occurred with respect to the baseline injury risk, and yet for which the exposure(s) of interest are uncorrelated.

In summary, the case-crossover design allows for a novel approach to evaluate factors that may lead to injury at the workplace. This approach leads to freedom from confounding by differences between workers that would be difficult if not impossible to overcome with more traditional approaches. Implementing such studies involves overcoming several important challenges just as in any other observational design.

C3.2 Animal-Related Injuries to Veterinarians: Application of the Case-Crossover Design—Gabel CL, Gerberich SG, Maldonado G

Injury epidemiology presents some unique study design difficulties, in addition to those usually encountered in observational epidemiology. Besides defining the relevant

hazard period, the acute and rapidly changing nature of this hazard period can make it difficult to measure exposures accurately.

The case-crossover design has been proposed as a way to study events related to acute exposures. This design enables each case to serve as its own control and facilitates comparison of exposures that vary over time for an individual, while controlling for those factors that are invariant. In contrast, a case-control design enables analysis of both types of factors by comparing case and control exposures.

In a recent study of risk factors for injuries among all Minnesota practicing veterinarians, several questions were included in the first phase comprehensive questionnaire to enable conduct of a case-crossover study. A nested case-control study was also conducted in a second phase of the overall effort. This provided an opportunity to contrast findings, pertinent to several potential risk factors, between the two study designs. A conceptual model provided the basis for the factors that were included in the study and the relevant analyses. Factors, that were addressed in this portion of the effort, were related to fatigue.

Exposure data for the case-crossover study were collected for the night prior to the event and for the month preceding the injury; data for the case-control (1:2 ratio) study were collected for the month prior to the injury (cases) or a randomly selected month (controls). Both univariate and multivariate analyses were conducted, relevant to the respective designs.

Results of this effort provide insight into the application of the case-crossover method. Advantages and limitations of both the case-crossover and the case-control design in injury epidemiology are identified.

C3.3 Transient Risk Factors for Occupational Acute Traumatic Hand Injury—Sorock GS, Lombardi DA, Hauser R, Eisen EA, Herrick R, Racine R, Mittleman MA

The National Electronic Injury Surveillance System reported that the most frequent occupational injury treated in hospital emergency departments in the United States in 1996 was a lacerated finger or hand. Potential transient risk factors for acute traumatic injury to the fingers or hand were studied using a case-crossover design. Patients were recruited from 21 occupational health clinics and three manufacturing companies in New England. A total of 1,128 subjects (874 men and 254 women) were interviewed a median of 1.3 days after the injury. The mean age was 37 +/- 11.4 (s.d.) (range 18-77). Of the total 1,360 injuries incurred by 1,128 subjects, 62% were lacerations, 13% crushes, 8% avulsions, 6% punctures, 5% fractures, 1% amputations, and 5% others. The occupations of the subjects were machine trades (33%), services (15%), construction (15%), manual materials handling

(9%), bench work/assembly (9%), managerial (8%) and others (11%).

The case-crossover design uses cases as their own controls to assess the change in risk of a sudden-onset event during a brief "hazard" period (e.g. 10 minutes before the injury) as compared to an earlier "control" period. The control period selected for this analysis was the average exposure (frequency times duration) in the work-month prior to the injury. We found relative risks and 95% CIs as follows: using malfunctioning equipment or materials RR=12.0, (10.2-14.1), doing a task using an unusual work method, RR=11.1, (9.2-13.4), doing an unusual task RR=6.6, (5.6-7.8), being distracted RR=5.4, (4.7-6.2), rushing RR=2.4, (2.1-2.8) and glove use, RR=0.6, (0.5-0.7). The case-crossover design perfectly controlled for differences between subjects like age, gender, and occupation.

These results suggest that certain work equipment, practices and environment factors significantly increase the risk of a hand injury and glove use significantly protects against hand injury.

C3.4 Temporal Factors and the Risk of Occupational Acute Hand Injury—Lombardi DA, Sorock GS, Eisen EA, Herrick RF, Hauser RB, Racine R, Mittleman MA

Both mental and physical fatigue have been considered potential risk factors in studies of fatal and non-fatal injuries in the workplace. To evaluate associations between traumatic injuries to the hand and potentially modifiable risk factors, we enrolled 1,128 patients in a case-crossover study of occupational hand injuries. Patients were recruited over two years from 24 occupational health clinics in New England. Four temporal factors were evaluated. These factors included 1) the time of day of the injury, 2) the time since start of shift, 3) working overtime, and 4) hours of sleep before the injury relative to usual number of hours of sleep.

The median age of the subjects was 36 years and 77.5% were male. The majority of hand injuries occurred in the morning between 09:00-12:00 (43.2%), peaking from 10:00-12:00 (29.8%). The median time of injury was 3.5 hours into the work shift. The average hours worked per month was 193, including 22.5 hours of overtime, representing 11.7% of the total person-time at risk. In contrast, only 4.0% of injuries occurred while working overtime. The mean and median difference in sleep time (hours) was -0.1 and 0, respectively.

Hand injuries tend to occur early into the workday and sleep time does not appear to be a risk factor. The apparent lowered risk during overtime requires further evaluation of worker schedules and the availability of health care clinics used for data ascertainment during that time period. Alternatively, work tasks may be different during overtime as compared with regular working hours. Additional analyses are also needed

to determine if these findings are modified by workplace, individual factors, or break periods during the work day.

Session: C4.0

Title: Mining

Category: Injury surveillance

Moderator(s): Lisa J. Steiner

C4.1 An Analysis of Serious Injuries to Dozer Operators at US Mining Sites—Wiehagen WJ, Mayton AG, Jaspal JS, Turin FE

This paper is concerned with serious injuries occurring to bulldozer operators working at domestic coal, metal and nonmetal mines. Injury data collected by the Mine Safety and Health Administration is summarized for dozer operators that incurred serious injuries while operating the equipment over a ten-year period (1988-1997).

An injury classification system was developed to code a set of fatal and nonfatal injuries. We categorize the data by activity (task being performed), result (what apparently happened to the dozer) and operator impact (how was the operator injured). Where information is available, contributing factors are identified.

The results of the study indicate that the number of serious injuries to dozer operators has declined by 30% over the time period. The reduction in serious injuries resulted in a matching reduction in days lost. This was found for all classes of dozer operator injuries: incidents due to jolts and jars, fall over / roll over, sprains and strains, struck against, and struck by.

Further reductions in injury risk will require: more widespread use of seat belts, field and laboratory research interventions to better assess the effect of alternative engineering (e.g., seat and seat suspension) designs to dampen or isolate the effects of shock and vibration, and continued attention on hazard awareness, recognition and response. Although the number of incidents have decreased, dozer operators being jolted and jarred accounts for the largest percentage (70% of the incidents) and severity (75% of the workdays lost) of serious injuries while operating the equipment.

C4.2 Haulage Truck Dump-Site Safety—Turin FC, Wiehagen WJ, Jaspal JS, Mayton AG

Dump-site injuries occur at all major mineral industries. Working in elevated areas near an edge is a common hazard for operators of off-highway mobile mining equipment. This report will examine serious injuries involving haulage trucks working at dump-sites for the period 1988 to 1997. Data were acquired from injury reports gathered by the Mine Safety and Health Administration (MSHA). This work is organized into three primary sections. The first presents an overview

of the frequency and severity of injuries. The second analyzes injury characteristics using MSHA defined data fields and author defined injury classifications. Key findings are discussed in the third section. In summary, 370 serious injuries were identified, 26 of these were fatalities. Although haulage truck dump-site activities resulted in a small proportion of surface mining injuries, these injuries were much more likely to result in death or significant lost time than most other surface mining injuries. The findings of this report support that haulage truck dump-site activities are worthy of continued study by those interested in improving the health and safety of workers at surface mines.

C4.3 Evaluating Safety Interventions in the U.S. Mining Industry—Coleman PJ, Kerkering JC

Traumatic injury prevention in the workplace is an ongoing challenge, particularly in high-risk industries such as mining. When a safety program is changed, or a new emphasis added, how can it be evaluated? What works and what doesn't? We outline one approach to this problem here.

In mining companies as in other industries, accidents often occur as events that can be modeled by a Poisson process. When safety program improvements are made, the expected reduction in accidents can also be modeled as a change in the process parameter. From a practical standpoint, if a reduction in accidents is observed over some time period, the hypothesis of a significant change in the underlying parameter can be tested using tail sums of binomials. Alternatively, confidence intervals for two observed accident counts in non-overlapping intervals can be compared. For typical mining companies wishing to assess whether changes in safety procedures have had a significant impact on injury rates, these comparisons are easily done but the power of such tests depends on the numbers of accidents being compared, or on the length of observation periods.

We used Mine Safety and Health Administration (MSHA) reported injury and illness databases to determine average values of reported accident counts for mining companies. Employment data for mines was also analyzed to obtain baseline values and variability over time. To facilitate the use of statistical tests to compare the effects of a safety intervention, tables were constructed based on the comparison of two Poisson rates. These provide confidence intervals for observed event counts from pre- and post-intervention periods. Methods were also developed to account for changes in employment or hours worked during the observation periods. We discuss ways in which these techniques can be used by employers, unions, and researchers to improve safety and health.

C4.4 Alternate Measures of Risk for Communicating Study Results: Comparisons of Injury and Chronic Disease Mortality in the NIOSH Colorado Uranium Miners Cohort—Park R, Stayner L, Bailer J, Gilbert S, Halperin W

Traditional measures of relative risk such as SMRs, Rate Ratios, and attributable risks or fractions, are often not meaningful or intuitive for many audiences. Using simple lifetable (SMR) and more powerful Poisson regression methods, we produced estimates of SMRs, attributable risk fraction, attributable years of potential life lost, and excess lifetime risk for both chronic disease outcomes (lung cancer, nonmalignant respiratory disease) and fatal injuries. These results provide stark summaries of the magnitude of work-related mortality among uranium miners. For example, for every year employed, miners on average lost almost 4 months of life expectancy just due to risk of subsequent work-related lung cancer. Although work-related chronic disease deaths dominated (due to radon, silica and probably other exposures), more years of life were lost on average, per individual injury death (37 yrs), than for a lung cancer death (20 yrs). In deriving meaningful statements on injury risk, it is especially important to describe consequences in terms of years of life lost due to hazards on the job as well as other epidemiological measures of risk.

Session: C5.0

Title: Intervention and Risk Factor Research

Category: Intervention Evaluation

Moderator(s): Linda Goldenhar

C5.1 Evidence on the Effectiveness of Measures Recommended to Prevent Workplace Homicide—Loomis D, Wolf S, Runyan CW, Marshall S, Butts JD

Government agencies have recommended that employers adopt measures to reduce the risk of homicide on the job. Their recommendations include both environmental design modifications and administrative actions. To investigate the value of recommended preventive measures, we analyzed data from a case-control study of homicide in North Carolina workplaces in 1994-98. Workplaces were the units of analysis: case workplaces were those where a worker's death resulted from homicide during the study period (n=105); control workplaces were an incidence-density sample of the study base, matched by industry sector (n=210). Data on safety measures and other workplace characteristics were collected by telephone interview. Conditional logistic regression was used to estimate the exposure odds ratio (OR) as an indicator of association. Among 13 environmental interventions examined, only the presence of a barrier between workers and the public (OR 0.5, 95% CI 0.2-1.2) was associated with a noteworthy reduction in risk. Keeping entrances closed during working hours (OR 0.5, 95% CI 0.2-1.1), special arrangements with a law enforcement agency (OR 0.4, 95% CI 0.2-0.8), pre-employment psychological screening (OR 0.5,

95% CI 0.2-1.5) and having more than one worker on duty (OR 0.4, 95% CI 0.2-0.7) were the only administrative measures associated with notably lower risk among the 13 considered. Some interventions, including installing surveillance cameras (OR 1.8) and mirrors (OR 1.7) posting cash-limit warnings (OR 4.2), employing security guards (OR 1.2), and training employees to respond to robbery (OR 1.6) were associated with higher homicide risk. Neither adjustment for community and employer characteristics nor restriction to the subset of killings that resulted from robbery substantially changed these results. These findings suggest that many measures recommended for reducing the risk of workplace homicide may not be providing adequate protection as they are currently implemented in industry.

C5.2 Risk Factors for Violence Among Nurses: Methods and Preliminary Results—Gerberich SG, Church T, McGovern P, Hansen H, Nachreiner N, Geisser M, Watt G

The purpose of this two-phase effort is to document the magnitude of work-related violence (phase 1) and identify relevant risk factors (phase 2) among the population of Minnesota nurses — one of the few readily accessible occupational groups. A conceptual model served as the basis for collecting exposure information and guiding the analysis. Pilot-testing was conducted prior to each phase. This paper presents preliminary results and the methods used to obtain quality violence incidence and exposure data.

To pilot-test phase one, 220 Registered Nurses and Licensed Practical Nurses were randomly selected from nursing license records (response rate 82%); phase two pilot testing involved 23 physical assault cases and 69 controls. Intensive follow-up methods (mail and telephone) were used to maximize the response rate; up to four follow-up efforts were incorporated in both phases. Pilot-testing revealed difficulty in quantifying the frequency of non-physical violence events. Thus, modifications were made to address ongoing events adequately.

Based on limited data from the literature, a conservative 5% assault rate had been estimated; however, the assault rate for eligible nurses was greater than expected — 17% in the pilot study, and 14% in the comprehensive study. Non-physical violence (threats, verbal abuse, and/or sexual harassment) was reported by 40% of nurses in the pilot study, and 38% in the comprehensive study. With the higher than expected assault rate, and the unexpected additional staff time necessary to conduct follow-up, the sample size was decreased from 12,600 to 6,300 for the comprehensive study, which still yielded an adequate size for the case-control study.

Work-related violence is a serious problem. This study is an important step in identification of the extent of the problem

and relevant risk factors that will facilitate the development of relevant prevention and control strategies.

C5.3 Workplace-Level Risk Factors for Homicide on the Job—Loomis D, Wolf SH, Runyan CW, Butts JD, Marshall S

Homicide is the second leading cause of death on the job for all US workers and the leading cause for working women. Risk factors for workplace homicide have been identified primarily through descriptive epidemiologic studies based on routine surveillance data, which do not allow detailed analysis. To investigate predictors of workplace homicide more thoroughly, we conducted a case-control study of homicides in North Carolina workplaces in the years 1994-98. Workplaces were the units of analysis: case workplaces (n=105) were those where a worker was killed during the study period, while control workplaces (n=210) were an incidence-density sample of the study base, matched by industry sector. Data on potential risk and protective factors were collected by telephone interview. Strength of association was assessed by the exposure odds ratio (OR), estimated via conditional logistic regression. Industries at especially high risk were taxi services (OR 25.1, 95% CI 4.05-), and grocery and convenience stores (OR 10.6, 95% CI 1.32- and OR 9.9, 95% CI 2.9-33.4, respectively). Employer characteristics associated with markedly higher risk included having been in business at the current location <12 months (OR 6.2, 95% CI 1.2-32), having only 1 worker (OR 2.9, 95% CI 1.9-7.2), and working at night (OR 4.9, 95% CI 2.7-8.8), or on Saturdays (OR 4.2, 95% CI 1.9-9.2). The occurrence of homicide was also associated with a history of robbery (OR 3.3, 95% CI 1.6-6.8) or violence against workers (OR 15.4, 95% CI 4.6-51.1) within the previous 2 years. In addition, workplaces with only male employees or with employees of only one race were more likely to experience a killing. While the preceding risk factors are not directly modifiable through classical workplace interventions, it is important to identify them and understand their interrelationships preliminary to developing or evaluating protective measures.

C5.4 Interventions for the Primary Prevention of Work-Related Carpal Tunnel Syndrome—Lincoln AE, Vernick JS, Ogaitis-Jones S, Smith GS, Mitchell CS, Agnew J

Objective: To evaluate interventions for the primary prevention of work-related carpal tunnel syndrome (CTS).

Selection Criteria: Studies included engineering, administrative, personal, or multiple component interventions with comparison data and applied to a working or working-age population. Outcome measures included the incidence, symptoms, or risk factors for CTS, or a work-related musculoskeletal disorder of the upper extremity that included CTS in the definition.

Results: Twenty-four studies met our inclusion criteria. Engineering interventions included alternative keyboards, computer mouse designs and wrist supports, keyboard support systems, and tool re-design. Personal interventions included ergonomics training, splint wearing, electromyographic biofeedback, and on-the-job exercise programs. Multiple component interventions (e.g., ergonomic programs) included workstation redesign, establishment of an ergonomics task force, job rotation, ergonomics training, and restricted duty provisions.

Multiple component programs were associated with reduced incidence rates of CTS, but the results are inconclusive because they did not adequately control for potential confounders. Several engineering interventions positively influenced risk factors associated with CTS, but the evaluations did not measure disease incidence. None of the personal interventions alone were associated with significant changes in symptoms or risk factors. All of the studies had important methodological limitations that may affect the validity of the results.

Conclusions: While results from several studies suggest that multiple component ergonomics programs, alternative keyboard supports, and mouse and tool re-design may be beneficial, none of the studies conclusively demonstrates that the interventions would result in the primary prevention of CTS in a working population. Given the lack of demonstrated effectiveness, intervention research should prioritize randomized controlled trials that include: 1) adequate sample size; 2) adjustment for relevant confounding variables; 3) isolation of specific program elements; and 4) measurement of long-term primary outcomes such as the incidence of CTS, and secondary outcomes such as employment status and cost.

Session: C6.0

Title: Engineering and Technology

Category: Engineering and Technology

Moderator(s): Karl A. Snyder

C6.1 Visual Reference Effect on Balance Control in Roof Work—Simeonov PI, Hsiao H

Falls from roofs are the leading cause of fatal fall injuries in the construction industry. From a biomechanical and psychophysiological standpoint the majority of occupational fall incidents, including falls from roofs, can be attributed to deterioration and disruptions in worker's balance control. Identifying the critical factors that could deteriorate the control of balance during roof work can help to develop effective fall-prevention strategies.

In a laboratory study we investigated the effects of height and close visual references on workers' postural stability and their interaction effects with roof slope, and roof surface

firmness. Workers performed standing tasks on inclined [(0°), 4/12 (~18°), 6/12 (~26°), 8/12 (~34°)] and compliant surfaces at height (0', 10', 30') with close visual structures included or excluded from their peripheral visual field. Workers' standing balance was determined from the movement of their center of pressure (CP) measured by a force platform.

The results from 10 subjects demonstrate that visual exposure to environments without close visual references significantly increased worker body sway parameters (velocity of sway, area of sway, RMS of ML and AP sway). These effects were compounded by surface firmness (i.e., unstable support), workplace height, and surface slope. Close visual references significantly reduced sway and restored some of the sway characteristics (AP sway and sway area) to their baseline values.

These data can assist the roofing industry in modifying the roof work environment for improving workers' posture stability. The results of this study may also be used to develop a methodology for roofers' safety training with focus on the role of visual factors.

C6.2 Computational Simulation of Electrical Arc Parameters—Capelli-Schellpfeffer M, Miller GH

There were over 540,000 electrical workers in the United States in 1992. Bureau of Labor Statistics data for 1994 show 11,153 cases of reported days away from work due to electrical burns, electrocution/electrical shock injuries, and fires and explosions. In 1994, the Census of Fatal Occupational Injuries noted 548 employees died from these exposures out a total 6,588 work-related fatalities nationwide. Electrocution is a frequent cause of construction-related fatality.

The clinical spectrum of electrical injury ranges from the absence of any external physical signs to severe multiple trauma requiring extensive surgical care. Reported neuropsychiatric sequelae can vary from vague complaints seemingly unrelated to the electrical injury event by their distance in time or apparent severity, to sequelae consistent with traumatic brain injury. In part, blast effects may explain why electrical injury patients without external signs of electrical contact may present with nervous system or hearing impairment.

Regarding arc blast to date there is no causal link that has been established to guide treatment decisions, assist in triage assessment, or serve as the basis for recommendations on future preventive measures. To investigate the possible etiologic relationships between electrical arc phenomena and electrical injury and fatality, we have pursued the development of computational models for electrical arc events including their acoustic component. Ultimately, the correlation between numerical simulations of arc forces and experimental data is expected to enhance understanding of the mechanisms of

electrical injury and fatality as well as to assist with safety standards for electrical work practices around energized equipment. For example, the hazard management of electrical arcs' acoustic component has not routinely been incorporated into electrical safety training. Progress with pilot 2-dimensional techniques, results of 3-dimensional simulations compared to high voltage test lab experiments, and training applications are presented.

C6.3 Development of a Computerized Audit Tool for Control of Construction Falls—Becker PE, Fullen MD, Akladios M, Carr M

West Virginia University has developed and deployed a computerized field audit to assist in the conduct of a safety intervention research project. The audit tool is used in the field on a touch screen hand held computer to monitor construction contractor compliance with a fall hazard management program provided by WVU. The field audit provides feed back to contractors, determines whether contractors can retain a Fall-Safe designation from WVU, and provides data to WVU on the impact of its intervention efforts.

The software is custom designed and incorporates questions that determine compliance with OSHA standards relating to falls. The audit tool generates percentage scores that indicate contractor successes in managing fall hazards. The algorithm that computes contractor scores rewards contractors for using engineering controls rather than personal protective equipment. The tool is intended to be field and user friendly. The tool has been field tested through 62 audits as plans are underway for its expansion and future development.

C6.4 Collision Warning Systems for Surface Mining Equipment—Ruff TM

In the past 5 years, powered haulage accounted for 43% of fatalities and was one of the top 5 sources of injuries in surface mines. Twenty-three of these fatalities occurred when a large capacity haulage truck ran into or over another vehicle in the truck driver's blind spot. One method of detecting an obstacle in the blind spot of large equipment and preventing a collision is to use some type of sensor technology such as radar or video cameras. Researchers at the Spokane Research Laboratory of NIOSH are testing off-the-shelf collision warning systems and developing new systems to meet the needs of the surface mining industry. This report summarizes the technologies available for this application, the advantages and disadvantages of each as determined by tests, and alternative sensor systems that are currently under development.

DAY TWO—WEDNESDAY, OCTOBER 18, 2000

Session: D1.0

Title: Tribology of Slip and Falls I

Category: Special Session

Organized by Mark Redfern, University of Pittsburgh

Moderator(s): Mark Redfern

D1.1 Field Evaluation of Two Commonly Used Slipmeters—Chang WR, Cotnam JP

A variety of slipmeters have been used to assess the slipperiness between shoe and floor surfaces. The operations of these slipmeters were outlined in their respective international standards for single measurements. However, these standards usually do not cover some critical elements in floor assessment such as how to select measurement locations and how many repeated measurements are necessary at each location. Furthermore, most slipmeters were evaluated in the laboratory setting with new floor surfaces and artificial contaminants. In this experiment, two commonly used slipmeters, the Brungraber Mark II and English XL, were evaluated in the kitchens of eighteen fast food restaurants. At each restaurant, four floor tiles in each of four different work areas were selected for repeated measurements with these two slipmeters. The work areas included the fryer, grill, sink and back door, where the potential for accidents in slips and falls was high. Measurements were taken during business hours. The floor conditions were not altered except that water was applied to the floor surface around the sink to simulate conditions when washing tasks were being performed. The typical contaminants on the tiles were grease near the fryer and grill, and water, dirt and food debris near the back door. At each location, 12 measurements were taken with each slipmeter. The Neolite shoe pads were sanded with 400 grit silicon carbide abrasive paper right before the first and seventh measurements.

The results of an ANOVA analysis showed statistically significant differences in friction among different tiles in some areas. Since the appearance of these tiles was very similar, a significant difference in friction coefficient could increase the potential of a slip and fall accident when employees fail to anticipate the floor conditions and respond accordingly.

D1.2 The Impact of Neolite Test-Foot Variability and Tribometer Type on Slip Resistance Measurements—Sapienza MA

To determine if either the Neolite test foot material used for friction measurement, or the tribometers themselves were in any way contributing to the measured results, we utilized a series of single factor designed experiments. The protocol involved three different types of pedestrian surfaces, official solid vinyl tile and official vinyl composition tile, obtained from the Chemical Specialties Manufacturers Association

(CSMA), and official ceramic tile, obtained from the Tile Council of America (TCA). All materials were used for the Niolite determination while just the official ceramic tile was used for the tribometer evaluation that included the James Machine, the Mark I PAST, the Mark II PIAST, and the VIT. The experimental design came from Box, Hunter, and Hunter, *Statistics for Experimenters*, John Wiley & Sons, Inc., 1978. The protocol consisted of a series of runs with each machine using different test-feet with one sample of each type of pedestrian surface. To minimize any inherent testing bias, the run series were randomized. Test results were analyzed using standard analysis of variance techniques. The between sample variances were compared to the within sample variances and a determination was made regarding the significance of the test-feet. This particular type of experiment assumes a null hypothesis. That is, the different test-feet will not have any significant effect on the test results. The results indicated clearly that 1) the null hypothesis must be rejected and that Neolite does, in fact, have a statistically significant effect on the test results and 2) friction is also dependant on what tribometer is used to measure it.

D1.3 The Evaluation of Two Commonly Used Slipmeters: The Repeatability and the Effect of Slip Criteria— Chang WR

A variety of slipmeters have been used to assess the slipperiness between footwear and floor surfaces. Although the operations of these slipmeters were outlined in their respective international standards, some of the critical elements in the measurement protocols were ambiguous. Two commonly used slipmeters, the Brungraber Mark II and English XL, were evaluated in this experiment. A systematic approach was established to obtain friction coefficients. Since the operators need to determine if a slip occurs in arriving at a friction coefficient, they often must develop their own criteria without proper instruction from the manufacturers of these slipmeters. Two criteria of slip conditions at the interface were used to cover all possible slip criteria that the operators might use. One criterion was that any movement at the interface was considered a slip. The second criterion was that only fast movement was considered a slip and, therefore, any slow movement, any finite dwell time at the impact or any partial stroke were considered as a non-slip. A total of 15 shoe materials and 3 floor materials were used in this experiment. The surface conditions included dry, wet, oily and oily wet. Three samples were used for each material combination and surface condition. Three measurements were taken from each sample. All the friction measurements were performed at a temperature of 70 ± 3 degrees F and a relative humidity of $50 \pm 5\%$.

The results of an ANOVA analysis indicated that the differences in friction coefficient among the three samples and between the two slip criteria were statistically significant for some material combinations and surface conditions. These

differences could contribute to the discrepancy in the results reported among different institutions due to different samples and different slip criteria used.

D1.4 Precision and Bias Testing of the English XL Variable Incidence Tribometer and the Brungraber Mark II Portable Inclinable Articulated Strut Slip Tester— Flynn JE, Underwood DC

Precision and bias testing was conducted on both the English XL and Brungraber Mark II tribometers. Six independent laboratories were involved with the English XL while ten independent laboratories participated in the study of the MK II. Each laboratory used their own tribometer to perform the measurements.

Three types of ceramic tile were selected to minimize changes in surface characteristics resulting from repeated testing. To minimize the effect of variability in the test surfaces, the same surfaces were sent to each of the study participants. In each case, the tiles were marked to specify the exact placement of the VIT and the MK II. In an attempt to minimize the differences between test feet, each participant used the same test foot. The test foot for each type of tribometer was fitted with Neolite® from Smithers Scientific. All of the surfaces were tested under both wet and dry conditions.

The results of the study were analyzed statistically according to ASTM Practice E691. When looking at the VIT, it was found that the average value of the repeatability standard deviation was 0.02. The average value of the 95% repeatability limit was 0.05. The average value of the reproducibility standard deviation was 0.03 and the average value of the 95% reproducibility limit was 0.09.

When looking at the MK II, it was found that the average value of the repeatability standard deviation was 0.04. The average value of the 95% repeatability limit was 0.05. The average value of the reproducibility standard deviation was 0.07 and the average value of the 95% reproducibility limit 0.19.

Bias was not established as there currently are no accepted standard surfaces to allow such comparison.

Session: D2.0

Title: Alaska's Model Program for Surveillance and Prevention of Occupational Injuries

Category: Special Session

Organized by George Conway, National Institute for Occupational Safety and Health

Moderator(s): George Conway

D2.1 Alaska's Model Program for Surveillance and Prevention of Occupational Injury Deaths—Conway GA, Lincoln JM, Husberg BJ, Manwaring JC, Klatt ML, Thomas TK

Background: The National Institute for Occupational Safety and Health (NIOSH) established its Alaska field station in Anchorage, Alaska in 1991 after identifying Alaska as the highest-risk state for U.S. traumatic worker fatalities. Since then, we have established comprehensive occupational injury surveillance in Alaska, and formed and facilitated interagency working groups (of state and federal agencies) to address major factors leading to occupational death and injury in the state.

Methods: Establishment of a surveillance system, obtaining information via data-sharing with jurisdictional agencies and from direct on-site investigation of incidents. Collaboration with state and regional government agencies, industry, workers, and non-governmental organizations to develop interventions. Translation of complex scientific manuscripts to “worker-friendly” texts for workplace dissemination.

Results: Since 1991, Alaska has experienced a 50 percent overall decline in work-related deaths by 1999, including a substantial decline in commercial fishing deaths, and a very sharp decline in helicopter logging-related deaths. These efforts have led to major national and international government-industry collaborative efforts in improving safety in helicopter lift operations, and a concomitant improvement in fishing industry mortality in workers fishing Alaskan seas.

Conclusions: Using surveillance data as information for action, these collaborative efforts have contributed to reducing mortality in Alaska's high occupational fatality rate. This has been most clearly demonstrated in the rapidly expanding helicopter logging industry. The application of surveillance data has also played an important supportive role in the substantial progress made in reducing the mortality rate in Alaska's commercial fishing industry (historically Alaska's (and America's) most dangerous industry, and largest killer of Alaskan workers). Results suggest that extending such a regional approach to other parts of the country, and application of these strategies to the entire spectrum of occupational injury and disease hazards could have a broad impact toward reducing occupational injuries.

D2.2 Preventing Fatalities and Severe Non-fatal Injuries in Alaska's Commercial Fishing Industry—Lincoln JM, Husberg BJ, Conway GA

Purpose: Fatalities and non-fatal injuries have been inordinately common in Alaska's commercial fishing industry. Over 90% of these deaths were due to drowning, following vessel capsizings/sinkings and 60% of the non-fatal injuries resulted from being entangled, struck or crushed by fishing equipment. The purpose of our study was to examine the effectiveness of the current safety measures in reducing the high fatality and non-fatal injury rate of Alaska's commercial fishermen.

Method: Alaska Occupational Injury Surveillance System and Alaska Trauma Registry data were used to examine fishing fatalities and injuries. Demographic, risk factor, and incident data were compiled and analyzed for trend.

Results: During 1991-1999, there was a significant ($p < 0.001$) decrease in Alaskan commercial fishing deaths. Although drownings from vessel-related events during the crab fisheries haven't decreased as much as in other fisheries, significant progress ($p < 0.001$) has been made in saving lives of fishermen involved in vessel-related events. Specific measures tailored to prevent drowning in vessel capsizings and sinkings have been very successful so far. However, these events continue to occur, placing fishermen at substantial risk. Additional efforts toward vessel stability, hull integrity, and avoidance of harsh weather conditions must be made to reduce the frequency of vessel events. From 1992-1997 there were 536 severe injuries (437/100,000/year) and there has been no significant downward trend of the most severe injuries (AIS >3). Injuries included fractures (257[50%]), open wound (64[12%]), burns (28[5%]), amputations (27[5%]), and contusions (27[5%]); 60% resulted from being entangled, struck or crushed by fishing equipment and 25% from falls. The nature of these fatalities and injuries reflect that modern fishing vessels are complex industrial environments posing multiple hazards. Measures are urgently needed to prevent and mitigate falls overboard and on deck, and improve equipment handling and machinery guarding.

D2.3 Pilot Inexperience May Increase the Hazards in Alaska, 1990-1998—Bensyl DM, Manwaring JC, Conway GA

Background: Vast mountain ranges and glacial ice impede road transportation in Alaska, making aircraft essential for providing goods and services. Professional pilots in Alaska have substantially increased risk for dying while working: over a 30-year career, they have an 11% chance of dying while working, compared to 2.5% for US pilots and 0.4% for non-pilot workers. To reduce this rate, determining factors underlying injury crashes is necessary.

Methods: Data were abstracted from National Transportation Safety Board summaries for 1990-1998 air taxi crashes. Air taxi flights are commuter/on-demand flights for compensation in an airplane/helicopter that begin and end at the same airport. Injury crashes (including fatalities) were compared to non-injury crashes by pilot flight-time experience, day or night, visibility, and number of passengers. Odds ratios were generated using logistic regression.

Results: During 1990-1998, 309 air taxi crashes occurred: 131 injury (49 fatal, 82 non-fatal), and 178 non-injury. Fifty percent of pilots involved in injury crashes were early-career (540-4800 hours experience) and 16% of those were very early-career (540-1800 hours). Logistic regression analyses showed a positive association for flight experience, diminished visibility, and involvement in an injury crash. For very early-career pilots, injury crashes were 22 times more likely to have occurred in low-visibility (Odds Ratio (OR)=22.49, Confidence interval (CI)=3.63-138.25). For early-career pilots (1801-4800 hours) injury crashes were six times more likely (OR=6.30, CI=1.80-22.07) to have occurred in low-visibility and for experienced pilots (>4800 hours) injury crashes were four times more likely (OR=4.43, CI=1.58-12.42) to have occurred in low-visibility. Night flying and passengers were not associated with injury crashes.

Conclusions: Air taxi injury crashes in Alaska might be decreased by improving pilot training in low-visibility conditions, especially for very early career pilots.

D2.4 Partnerships for Surveillance and Prevention of Occupational Aviation Injuries in Alaska—Manwaring JC, Bensyl DM, Conway GA, Perry D, Kobelnyk G

Introduction: The NIOSH, Alaska Field Station is addressing the problem of work-related aviation fatalities in Alaska through interagency partnerships, a compelling problem. Although Alaska has experienced an overall downward trend in occupational fatalities since 1990 (80 fatalities in 1990 to 38 fatalities in 1999—a 52% decrease), occupational aviation fatalities continue to be a problem. Aircraft crashes are now the leading cause of occupational fatalities in Alaska.

Methods: Aircraft accident data for crashes occurring in Alaska during 1990-1999 were obtained from the National Transportation Safety Board (NTSB) accident reports and entered into a database maintained by FAA's National Aviation Safety Data Analysis Center (NASDAC). Accidents specific to Alaska were selected and entered into a database maintained by NIOSH's Alaska Field Station—the Alaska Occupational Injury Surveillance System (AOISS) for analysis.

Results: Between 1990-1999, aviation crashes in Alaska caused 106 occupational pilot deaths, equivalent to 430/100,000 pilots/year, approximately 86 times the mortality rate

for all U.S. workers. Contributing to this problem was helicopter logging. During 1992-93, Alaska helicopter logging pilots had an extraordinarily-high crash rate of 16% annually, and catastrophic fatality rate of 5,000/100,000/year. In response to this problem, an interagency working group involving FAA, NTSB, NIOSH, and other federal and state agencies conducted surveillance, analyzed data, developed consensus safety recommendations, and assisted in implementing immediate improvements in the oversight of helicopter logging. As a result, from 1994, through 1999, there has been only one logging helicopter crash, with one fatality.

Conclusions: As demonstrated by the helicopter logging experience in Alaska, interagency partnerships can be highly effective in conducting surveillance and analysis, and recommending intervention strategies for the prevention of aircraft crashes. Building on this success, an interagency partnership—the Alaska Interagency Aviation Safety Initiative is focusing on surveillance and prevention of fixed-wing commercial aircraft crashes in Alaska.

D2.5 Fatality Assessment and Control Evaluation in Alaska—Choromanski, DM

The Alaska Fatality Assessment and Control Evaluation (FACE) project conducts research on occupational fatalities in Alaska as part of a National Institute for Occupational Safety and Health (NIOSH) grant-supported program. The purpose of FACE is to identify work-related deaths, collect data for a state and national database, review the circumstances preceding fatal incidents, and identify potential prevention strategies. During 1990 through 1999, 645 work-related deaths were identified, an average of more than 64 deaths per year. Of these 645 deaths, 450 occurred after July 1992, when the Alaska FACE program began. The number of fatal work-related injuries has decreased as the labor force in Alaska continued to grow, particularly in the construction, air transportation, communication, and retail sales industries. Forty-three percent (195/450) of the fatalities were white males between 22 and 51 years of age. Overall, drowning/hypothermia, aircraft crash injuries, homicides, and motor vehicle injuries accounted for two-thirds of all fatal traumatic occupational events, while 15% were attributed to crush or struck-by (impact) injuries: crush or struck-by injuries caused 15 (78.9%) of 19 logging deaths and 10 (76.9%) of 13 machinery-related deaths. The majority of non-aviation and commercial fishing events involved one or two victims. Nearly 72 % of non-aviation, non-commercial fishing work-related deaths occurred in sparsely populated, remote sites. While 40% of the notifications of fatalities were by state and federal agencies, newsmedia (local newspapers, television, and radio) accounted for nearly half of the initial reports of fatalities. Alaska's high rate of traumatic occupational death is, in part, a function of the distribution of workers in hazardous industries and high-risk environments. Data from the FACE project has

enabled public health, safety, and industry professionals to develop targeted interventions and reduce the high rate of occupational fatalities.

D2.6 Surveillance and Prevention of Nonfatal Work-Related Injuries in Alaska—Husberg BJ, Conway GA

The Alaska Trauma Registry (ATR) has been used as a population based tool for injury surveillance of nonfatal injuries in Alaska since 1991. This paper will cover injury surveillance using the ATR and how that information has been used in community injury prevention projects.

To be included in the ATR, patients either have to be admitted to a hospital, transferred from an Emergency Department (ED) to a facility with a higher level of care, or declared dead in the hospital. Data for the ATR is collected retrospectively from medical record charts. Over 150 data elements are collected in the ATR including cause of injury, nature of injury, and body region injured.

Currently the ATR has information for 3,230 work-related injuries occurring from January 1991 through December 1997. Commercial fishing (536) and construction (532) led the industry categories for number of occupational injuries. The industry with the highest injury rate was logging with 22.75 injuries per 1,000 workers. The most common causes of injuries in the fishing industry were caused by machinery (177) and falls (127). In the construction industry, different types of falls (263) lead all causes with falls from or out of building (72), fall on or from ladder (50), and fall on or from scaffolding (41). The leading causes in the logging industry were being struck by an object (117) and falls (41).

The ATR has assisted us in prioritizing industries and causes for injury prevention. The Alaska Marine Safety Education Association uses ATR information to focus on fishermen alerts and training. The Alaska Injury Prevention Center has begun focusing on fall prevention education in the construction industry. Local timber harvesting groups are beginning to use ATR data for monitoring effectiveness of injury prevention programs.

Session: D3.0

Title: Challenges in Assessing Exposure to Occupational Injury Hazards

Category: Special Session

Organized by Dana Loomis, Department of Epidemiology, University of North Carolina

Moderator(s): Dana Loomis

D3.1 Dealing With Variability of Hazards in Occupational Injury Epidemiology—Kromhout H, Loomis D

Injury epidemiology has been very traditional with respect to exposure assessment. Evaluation of risks has been based on

job titles or personal attributes, like sex and age. Nevertheless, we know that hazardous circumstances are not permanently present or present with the same intensity. In order to make better inferences on causative factors leading to injuries, a better understanding of the variability in these factors will become a necessity. Much can be learned from recent advances in related fields of occupational cancer and respiratory disease epidemiology. Understanding of variability patterns in chemical and physical exposures has improved strategies for assessing and assigning exposure. For example, recent research on exposure to magnetic fields showed that health effects would have gone undetected had more traditional approaches to exposure assessment been applied. Variation in exposure has two fundamental dimensions: person and time. Variability between groups of people is a fundamental requirement for most epidemiological research. Exposure may also vary within groups and within individuals, however. The dimensions of exposure variability can be described quantitatively by the expression $X_{ij}(t) = f(\mu + \alpha_i + \beta_j + \theta)$, where $X(t)$ is instantaneous individual exposure at time t , μ is the overall mean exposure level, and α , β , and θ respectively represent deviations from μ associated with being a member of group i , being the j -th person in that group, and temporal fluctuation of exposure at time t . Opportunities for improved hazard assessment in the field of occupational injury epidemiology will be sketched based on these concepts and experience with other workplace agents.

D3.2 Variability, Measurement, and Analysis of Hours of Exposure in a Cohort of Fishers—Marshall SW

Occupational epidemiologists and industrial hygienists have developed methods for modeling exposures to environmental agents, such as dusts and chemicals, but these methods have not been widely applied to injury hazards. We illustrate the general approach using preliminary data from a cohort of fishers in Eastern North Carolina. Hours spent working on the water was assessed on a weekly basis throughout the fishing season. We partition the variation in weekly hours worked into two components, between-worker variance (F_B^2) and within-worker week-to-week (F_W^2) variance, using a multilevel random effects model. Risk ratios (RR) and confidence intervals (CI) for weekly hours worked were estimated from the model.

The ratio of between-worker variation ($s_B^2=1.40$) to within-worker variation ($s_W^2=0.40$) was 3.5, indicating that the majority of the variation in weekly hours worked was due to differences between fishers. The range of variation was quantified by calculating, from the model, the ratio of the 97.5th percentile to 2.5th percentile of the distribution of hours worked. This ratio was 102.8 hours for the between-fishers component and 11.9 hours for the week-to-week within-fishers component.

Crabbing was associated with the least time spent on the water (RR=1, referent category), while clamming (RR= 2.91; 95%CI: 1.46-5.83) and shrimping (RR=2.05; 95%CI: 0.64-6.54) required the greatest time. Finfishing (RR=1.46; 95%CI: 0.97-2.19) and oystering (RR=1.46; 95%CI: 0.70-3.04) were intermediate. Mixed operations required more time on the water than operations involving only one type of fishing (RR=1.81; 95%CI: 1.24-2.63). Future analyses will examine the role of seasonal and meteorological factors.

Whenever they are on the water, fishers are exposed to many important but non-modifiable hazards, e.g. unpredictable changes in local weather conditions. Increasing our understanding of the reasons for variation in work patterns presents an important (and possibly the only) opportunity for reducing exposure to these environmental hazards.

D3.3 Measuring Transient Occupational Injury Exposures—Sorock GS, Lombardi DA, Hauser R, Eisen EA, Herrick R, Mittleman MA

Case-only designs, such as case-crossover studies, use cases as their own controls and compare exposures immediately before the injury (hazard period) to earlier control periods in the same individual. This study design eliminates confounding by differences between individuals, allowing investigators to focus on transient exposures occurring in the workplace. Some examples of transient risk factors that may be studied include personal protective equipment, staffing level, and antihistamine use. These transient risk factors are the focus of the investigation rather than fixed risk factors like age, gender, industry, and occupation. Such transient factors may be more modifiable than fixed ones that can be evaluated as potential effect modifiers.

We used the case-crossover study design and interviewed 1,128 subjects (874 men and 254 women) a median of 1.3 days after an acute traumatic hand injury. The majority of subjects (69%) reported at least one of eight transient exposures during the 90 minutes before the injury. Some problematic areas were noted: 1) knowing the average duration of each transient exposure under investigation before selecting the control periods to avoid correlation of transient exposures over both the hazard and control intervals; 2) selecting control periods when the injury occurred at the beginning of the work shift or in the first month of employment; and 3) relying on self-reported exposures and their timing and the lack of any gold standard for comparison. These problem areas will be illustrated and plans for questionnaire reliability and validity assessments will be discussed.

Session: D4.0

Title: Fire Fighter Safety

Category: Injury Surveillance

Moderator(s): Thomas P. Mezzanote

D4.1 Traumatic Occupational Injury Fatalities to Fire Service Personnel, 1992-1998—Ta ML, Fosbroke DE

Firefighting tasks are performed in varied and dangerous environments posing unique hazards for increased risk of injury and death. Data from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI) and the National Fire Protection Association's (NFPA) annual firefighter fatality reports were analyzed to characterize the pattern and quantify the risk of traumatic occupational fatalities among workers in the fire service. Analysis was limited to civilian firefighting and fire inspection/prevention occupations, including supervisors. Denominator data for rate calculations were derived from the Current Population Survey and the NFPA's Fire Department Survey.

From 1992-98 CFOI documented 280 fatal traumatic occupational injuries to fire service workers, a majority (90.4%) of which occurred among firefighters. During this 7-year period, the average fatality rate was 9.0 per 100,000 employed career fire service workers, compared with 4.9 per 100,000 for all workers. Among volunteers, the fatality rate was 3.5 per 100,000.

Fires/explosions and transportation incidents were the main injury events. Fatalities from fire/explosion events predominately resulted from: collapsing structures (25.0%), entrapment (23.2%), and smoke inhalation (17.9%). Leading fatal transportation events were distributed among highway (60.6%), pedestrian (20.2%), and non-highway (7.3%) incidents. Motorized highway vehicles were the major injury source, accounting for 36.4% of all fatalities. Second to firefighting, activities involving vehicular and transportation operations were the next most hazardous worker activity. Over half (53.3%) of all transportation-related fatal injury events occurred among volunteers. Compared to those who work for pay or compensation, volunteers had 2.5 times the odds of being fatally injured in transportation than fire/explosion events.

Vehicle and transportation operations were a prominent cause of traumatic fatal occupational injury, especially among volunteers. While fatality data support the need to focus firefighter training on fire suppression activities, reduction of firefighter fatalities also require training to address motor vehicle hazards.

D4.2 The Relation Between Age & Duty-Related Injuries in Urban Fire Fighters I—Beaton R, Johnson C, Salazar M, Murphy S

Urban firefighters perform a variety of labor-intensive duties and tasks including fire suppression, rendering emergency medical services, and extrication/rescue. In 1997, the annual incidence of duty-related injuries in U.S. firefighters (40%) was nearly six times the average reported by other private sector U.S. worker groups.

The purpose of this investigation was to identify risks associated with firefighter age as well as protective factors for duty-related injuries employing a cross-sectional analysis of survey data obtained from two U.S. metropolitan fire departments. In a NIOSH surveillance study firefighter participants were asked to report if they had “been physically injured in the line of duty within the past year,” and whether they were “still experiencing the after effects of this injury.” Participants also reported the type of line-of-duty injury experienced.

Sample(s): Participants who completed surveys between 1995-1997 from their respective departments (n=382 and n=158) comprised the total firefighter sample (N=540). Approximately 90% of the potential respondents from each department participated. The average age of the total participant sample was 38 y.o., with an average of 11.25 years of service.

Analyses, Results, & Conclusions: Respondent data were analyzed by decade-age cohorts consisting of firefighters in their 20’s (n=95), 30’s (n=207), 40’s (n=188), and 50’s (n=47). In the older cohorts, there was significant increase in both the percentage of firefighters reporting duty-related injury (2=12.37; df=3; P<.01) and in the percentage reporting the “after-effects” of their duty-related injury (2=36.14; df=3; P<.001). The most commonly reported injuries were musculoskeletal.

In a series of logistical regression equations, firefighter age and department were shown to correctly categorize “on-the-job” injuries in 67.7% of cases. However, neither rank, gender, nor any reported health habit improved predictions of duty-related injury status. Explanations of these findings and implications for firefighter training and policy formulation are considered.

D4.3 A Prospective Longitudinal Study of Duty Related Injuries in Urban Fire Fighters—Johnson CL, Beaton R, Lewis E, Ollis T

Urban firefighters, by virtue of the often dangerous and labor-intensive emergency duties they perform, have an annual incidence of on the job injuries that is nearly six times the average reported by other private sector U.S. worker groups (IAFF, 1997). Exploring longitudinal data obtained from two

U.S. metropolitan fire departments, the purpose of this investigation was to identify variables (both risk and protective factors) which might predict future duty related injury status (Injured: Yes/No).

Methods and Sample: In a NIOSH surveillance study firefighter participants from two urban fire departments were asked to report if they had “been physically injured in the line of duty within the past year.” Survey data were then collected from the firefighter participants every six months for the next 18 months. Subjects who were uninjured at baseline were selected for analysis (n= 185) and classified with regard to a subsequent job-related injury in the 18 month follow up period (Subsequent Injury: Yes/No). Baseline measures of demographics as well as symptoms and sources of stress were examined as potential variables predictive of future on the job injury.

Findings and Conclusions: Results identified self reported symptoms of stress (SOS Total score) (r=0.22 p<0.01), reported concerns about potential “reductions in force, wages and benefits” (r=0.22 p<0.01), and “conveying news of tragedy” (r=0.21 p<0.01) as the most powerful predictors of future duty related injury in this sample. However, neither participant age, rank, nor any other demographic variable were significant predictors of future injury. Explanations and limitations of these findings as well as of implications for firefighter policy and training are considered.

D4.4 Fire Fighter Fatality Reports and Their Importance to the Volunteer Fire Service—Schafer HS

The National Volunteer Fire Council (NVFC) participated in a workshop to determine the level of detail, content and distribution of the National Institute of Occupational Safety and Health’s (NIOSH) Fire Firefighter Fatality Investigation and Prevention Program.

The purpose of the program is to determine factors that cause or contribute to firefighter deaths suffered in the line of duty. The outcome of the reports are distributed in many ways including mailings to the major fire service organizations and postings on the NIOSH website.

The reports are beneficial to the volunteer fire service for a variety of reasons. These include prevention of firefighter death and injury. The NVFC has used the informative reports to educate the volunteer fire service through its newsletter and website. Oftentimes, the recommendations made require additional funding for equipment, training, etc. The NVFC educates members of Congress through the reports as well.

Most recently, a report identified that if firefighters involved in a wildland fire had had more equipment, lives may have been saved. This type of equipment is made available to volunteer firefighters through the Volunteer Fire Assistance

program. This program is woefully underfunded and receives \$24 million in annual requests when less than \$3 million is awarded. If proper funding were in place, firefighters lives may be saved.

Session: D5.0

Title: Construction

Category: Intervention Evaluation

Moderator(s): Robert Chapman

D5.1 Fall-Safe Intervention and Research—Becker PE, Fullen MD, Akladios M

Falls are the leading cause of injury in construction. The construction safety literature recognizes available engineering controls, work practices, and personal protection which are effective in preventing construction falls. However the equipment and practices are not widely used in the industry. This presentation will report the results of an innovative intervention research project intended to improve and evaluate contractor performance and practices needed to decrease construction falls.

The program implements a construction contractor certification program called Fall-Safe. Fall-Safe is a fall management system that works to improve management use of existing fall prevention methods through use of training and an audit system to provide accountability system for fall prevention on construction job sites. WVU Safety and Health Extension serves as the certifying organization for contractors in West Virginia, and is assisting contractors in developing office and site fall prevention programs, training of supervision and workers, and quarterly audit of both company and site fall prevention efforts. Considerable project resources have been allocated to marketing the program to contractors. Construction Safety Council and St. Paul Insurance also serve as sponsoring organizations for Fall-Safe in the Midwest.

The site audit of fall prevention practices also serves as the tool for evaluating impact of the program. The audit has been programmed into a touch screen handheld computer that scores contractors on their fall prevention site programs and their compliance with OSHA standards related to construction falls. The evaluation compares the changes in scores for an intervention group of contractors and a control group that does not participate in Fall-Safe over a period of one and a half years. Preliminary analysis indicates intervention contractors improve both program and site audit scores more than control contractors.

D5.2 Differences in Injury Intervention Implementation Among Small Union Carpentry Firms in New England—Siqueira E, Halperin K, Ginieres M

An intervention to lower injury rates and improve safety practices among construction workers was implemented in January, 1997. The intervention consisted of assisting each of 21 small (10 to 50 carpenter) union carpentry firms in developing a health and safety program that they could apply to each new work site. Outcomes measured were insurance experience modification rates (EMR), injury rates measured by dividing OSHA recordable injuries by carpenter hours worked, and safety sentinel practices - use of hardhats, eye protection, hearing protection, electrical protection, and fall protection. Sentinel practices were measured every two to three months for at least one worksite for each firm. Controls were historical; additional controls for sentinel practices were measured by measuring the sentinel practices of carpenters at work on similar sites on the same days as the study group worksite visits.

Interviews with foremen of companies participating in an injury intervention research study and with carpenters' union stewards were conducted to qualitatively assess the factors that may explain why some contractors bought-in the proposed health and safety program while others did not.

A summary of the perceived reasons for success or failure of the health and safety intervention will be presented, using the themes and words of these two central actors in safe work practices in the construction industry.

D5.3 A Controlled Prospective Injury Intervention for Small Union Carpentry Firms in New England—Halperin KM, Cameron W, McDougall V

In January, 1997, an intervention was introduced which consisted of assisting 21 small union carpentry firms in developing health and safety programs. Outcomes measured were "sentinel safety practices": use of hardhats, eye protection, hearing protection, electrical ground fault protection, and fall protection on the construction worksite. Sentinel practices were measured every two to three months for at least one worksite for each firm. Controls for these "sentinel practices" were obtained by measuring the same variables at worksites of contractors not in the study group, on the same days as the study group worksite visits. Workers' compensation insurance experience modification rates (EMR) and OSHA recordable injury rate data were also collected for the study group contractors, but this proved difficult to control for except using historical internal controls within the study group.

Data collected in over 500 worksite visits show a correlation between the sentinel safety practices and the project ownership, project manager leadership on safety, contractor

leadership on safety, union local (and apparently union density), and type of carpentry work. There was an upward secular trend in safety equipment use over the three-year duration of the study among both the study group and controls.

Important lessons for further intervention research were learned. Simply instituting a written health and safety program is an inadequate intervention to affect either safety practices or injury rates. Physical safety measures - engineering measures and protective equipment policy measures - must be taken in order to improve the injury picture in construction.

D5.4 Worker and Manager Perceptions of Construction Safety Practices—Gillen M, McCall C, Sum J, Kools S, Moulden K

Aim: Experience has demonstrated that large construction companies have been successful in reducing work-related injuries on well-managed sites. Using focus group methodology, the aim of this qualitative study was to identify construction workers' and construction managers' views regarding currently used safety practices. Questions were designed to elicit information on direct safety practices such as equipment and training, but also indirect practices for example, communication style, attitude, expectations, and unspoken messages.

Methods: A series of nine focus groups was held with union and non-union carpenters, union roofers, and a mixed group of trades. Seven questions were used to elicit opinions from the construction workers. A second series of three focus groups was held with construction safety personnel or construction managers. Questions for the manager groups were developed, in part, from the worker responses, as well as theoretically and practice derived questions.

Analysis: Thematic content analysis was used to determine major themes in both series of groups. Findings suggest that safety management is a complex phenomenon requiring technical, interpersonal, educational, management, and organizational skills. Management commitment to safety, modeling safe behaviors, explicit and implied messages, worksite planning, housekeeping efforts, and personal interactions affect employee morale, and subsequently may contribute to safe work practices. The role of regulatory agencies, the insurance industry, workplace culture, and individual and co-worker behavior was also explored.

Conclusions: These findings may assist construction workers and managers in evaluating their safety behavior and safety practices, as well as developing new skills that may enhance their effectiveness in contributing to or managing workplace safety. When applicable, these findings may also be used to

develop cost-effective, model safety and health programs for small construction firms.

Session: D6.0

Title: Special Populations

Category: Special Populations

Moderator(s): Letitia Davis

D6.1 The Prevalence and Patterns of Occupational Injury in South Texas Middle School Students—Weller NF, Cooper SP, Tortolero SR, Kelder SH, Hassan S

Introduction: Emerging evidence suggests that substantial numbers of middle school youth are working during the school year. Like their older adolescent counterparts, these youngsters may be at risk for various occupational hazards, including work-related injury, already documented as a substantial public health problem in secondary students. Except for isolated reports of injuries/fatalities among young workers, information about the extent and nature of the work circumstances of these pre- and early-adolescents is scarce. Also sparse are data on the work experiences of special populations of disadvantaged or minority youth from rural geographic areas in the Southwestern U.S. This paper describes the prevalence and patterns of occupational injury in 6th, 7th, and 8th graders from South Texas, where Hispanic and economically-distressed youth are heavily represented.

Methods. Anonymous surveys were conducted in student's regular classrooms in May of 1995 (n=2,965 workers). Self-reported data included typical weekly work hours, work injury, type of injury, and type of job.

Results. Twenty-five percent of employed students reported an occupational injury (n=773). Of the injured, 30% required medical help (n=232). A dose response effect was observed: increasing weekly work hours were significantly related to work injury (1-10 hours, Odds Ratio [OR] = 1.0; 11-20 hours, OR = 1.5; 21 + hours, OR = 2.4), $p < 0.0001$ for chi-square linear-by-linear association. The likelihood of injury for males (32%) was greater than for females (18%), $p < 0.0001$. Significant multivariate logistic regression variables included agriculture (OR = 3.3), restaurant work (OR=3.2), construction (OR=2.4), retail work (OR=1.7), working 21+ hours weekly (OR=1.8), and male gender (OR=1.5).

Conclusions: This study demonstrated that intense work during the school-year increased the likelihood of occupational injury in middle schoolers. Parents and professionals should supervise school-year work hours. Increased prevention efforts should be targeted to young workers to reduce and prevent work injuries.

D6.2 The Prevalence and Risk Factors Related to Falls During Pregnancy—Dunning K, Lemasters G, Bhattacharya A, Levin L

Introduction: Although falls during pregnancy are a common cause of injury, there is minimal information regarding risk factors. During pregnancy, physiological changes occur that increase the risk for falls such as weight gain, loosening of ligaments resulting in joint laxity, swelling, and mechanical loading changes. At this time, there is no surveillance system for the pregnant worker and, therefore, little is known about their injuries. The purpose of this pilot study was to determine the prevalence rate and risk factors of falls during pregnancy.

Methods: A questionnaire was designed to determine pregnancy fall rate, injuries and medical attention, and risk factors. In order to capture a larger portion of the sample, two methods of questionnaire administration were utilized that include a 15 minute telephone interview and a four page mail survey. In partnership with the Hamilton County General Health District and the Cincinnati Health Department, 700 recent new mothers were identified from their child's birth certificate.

Results: To date, the participation rate is 61.2% (n=429) including 222 by telephone and 207 by mail. Most women, 76.4% (n=328) were employed during pregnancy and of those employed, the fall rate at work was 6.4% (21/328). Overall, 23.8% (102/429) of women reported a fall during pregnancy. When asked the location of their most serious fall, 12.7% (13/102) described their workplace. The highest number of falls (70%) occurred during 6-8 months of gestation. Of the women who fell, 68.6% (70/102) reported injuries and 37.2% (38/102) sought medical attention. Primary factors that the women related to their falls included stairs, a hurried pace, and walking on a slippery surface.

Conclusion: Given that 70% of women over age 20 work during their pregnancy and 6.4% will have a fall while working, there is a need to reduce risks of falls and injuries for this special population.

D6.3 Fatal Occupational Injuries Among Hispanic Workers of Texas—Mireles MC, Richardson S, Herrmann K

This descriptive study examined fatal occupational injuries among Hispanic workers in Texas from 1993 to 1997. For that period, the Census of Fatal Occupational Injuries, which is administered in Texas by the Texas Workers' Compensation Commission, provided a comprehensive data set of 2,451 occupational fatality cases in the state, of which 671 (27%) cases involved Hispanic workers. Calculation of crude fatality rates was based on estimated Hispanic workforce from the Current Population Survey. Coding of injuries was standardized by the use of the Occupational Injury and Illness Classification System.

The mean age for Hispanic fatal cases was 37, compared to 43 for non-Hispanic cases. Among Hispanic fatalities, wage and salary workers comprised 86% of the total number of fatalities. Specifically, construction laborers represented 30% of the cases. However, a comparison of crude fatality rates by industry showed the highest risk of 58/100,000 for Hispanic workers in mining, followed by 20/100,000 in construction, and 16/100,000 in agriculture. By occupation, operators, fabricators, and laborers cumulatively represented 45% of Hispanic cases, but workers in occupations related to farming, forestry, and fishing had the highest annual average rate of 15/100,000.

Events classified as "highway incidents" accounted for the greatest number of Hispanic fatalities (34%), but the most frequent event attributable to deaths on the job (10%) involved firearms. Being struck by a falling object was the second most frequent event of fatalities (6%). Assaults and violent acts remain a major concern for Hispanic workers, especially women, in the retail trade industry.

D6.4 Reducing Injury Risk of Students in Vocational-technical Schools and Young Workers in Small Businesses—Palassis J, Sweeney Haring M

NIOSH estimates that in USA each year 200,000 adolescent workers suffer work-related injuries. Many States mandate that vocational schools and small businesses have safety and health programs, conduct hazard analysis, and do safety inspections, maintenance, and comply with safety, health, and environmental regulations. To address these needs, NIOSH has taken a leading role to reduce injury risk by increasing safety and health awareness and safety education of vocational school students, teachers, administrators, and small businesses owners. NIOSH in conjunction with Environmental Occupational Health Sciences Institute of NJ developed an occupational and environmental safety checklists program. This program contains instructions on how to establish, implement, and maintain an occupational safety, health, and environmental program within the school and small business. It is comprised of over 80 safety checklists that cover occupational and environmental hazards found at schools and especially in the shops and small businesses. The program helps the user prepare for and participate in OSHA- and EPA-type compliance inspections. It enables the users of the checklists to identify occupational safety and health and environmental hazards and areas that need improvement. It can be utilized by the teachers, students and young workers to help them learn about government regulations pertinent to their shop and workplace. The program provides technical assistance, resources, and guidance to ensure that the school is in compliance with occupational safety and health and environmental regulations. The document is being finalized and will be available in print, CD-ROM, and on the NIOSH web site.

D6.5 A Report on Young Teens Experience With Occupational Health and Safety Issues: A Pilot Study—
Simoyi P, Frederick L, Niezen C, Hobbs G

Tens of thousands of young people are seen in hospital emergency departments each year for work-related injuries; some require hospitalization and over 70 die of work-related injuries. Students in the 9th and 10th grades in the three high schools in West Virginia completed one of three pre-tested questionnaires according to their work status (i.e., never worked, currently working, and previously worked). Questions covered topics such as knowledge of child labor laws, perceptions and attitudes toward occupational safety, the nature/extent of on-the-job injuries and exposure to hazards. A total of 1213 (78%) students completed the survey - 14% reported previously working, 4% were currently working and 82% had never worked. We combined the previously and currently working into one group, ever worked, for comparison to those who had never worked.

The ever worked students reported employment mostly during summer months June to August (36%) mainly in recreational facilities (15%), fast food and other restaurants (13%) and construction (9%). The main tasks performed were cleaning (20%), cashier (12%) and construction site (9%). Cuts (30%) burns (14%) and back injuries (8%) were the main injuries reported. Although students recognized some aspects of Child Labor Laws and OSHA, their perceptions of issues such as who is to blame when a teenager is injured was cause for concern. More than 46% of both groups believed that accidents just happen, 37% blamed the teenager and 16% thought the boss was at fault. These results suggest the need for adding an occupational safety and health component to the work-based experience that prepares students for adulthood responsibilities at work.

D6.6 Latino Immigrant Workers in Residential Construction: A Qualitative Study of Risk Factors—
Simoyi P, Frederick L, Niezen C, Hobbs G

This presentation will report on the results of a qualitative study of Latino immigrants working in the residential construction industry in North Carolina. A number of studies of immigrant workers have found unusually high injury rates among this population. Limited data from the North Carolina Department of Labor also suggest that Hispanics experience a disproportionate rate of injuries and fatalities on the job. This study examined the possible factors that may contribute to higher injury rates among Latino immigrant workers in construction. Fifty workers were interviewed for the study using a mix of open- and closed-ended questions on issues relating to training, availability of personal protective equipment, workers' knowledge and attitudes about safety, and language barriers.

The study found that a number of factors may contribute to higher injury risks among this population including: 1) lack of regular safety training/information; 2) inadequate communication by employers despite attempts to provide training in Spanish; 3) low education/literacy problems in Spanish as well as English; 4) discriminatory treatment by some employers; 5) workers' perceptions regarding their rights to safe working conditions; 6) workers' lack of knowledge of U.S. safety standards and laws; 7) workers' immigration status and fear of raising safety concerns with employers; and 8) workers' financial needs taking precedence over safety.

We will report on some of the key barriers to job safety identified by study participants and on recommendations that resulted from the research.

Session: E1.0

Title: Tribology of Slip and Falls II

Category: Special Session

Organized by Wen-Ruey Chang, Liberty Mutual Research Center for Safety and Health

Moderator(s): Wen-Ruey Chang

E1.1 The Contribution of Dry Contaminants to Slip Potential—Thorpe SC, Lemon PW, Jefferies SL

The majority of the research into pedestrian slipping to date has concentrated on the effects of the presence of wet contamination at the shoe/floor interface.

Although site-based experience, and Health and Safety Executive (HSE) statistics, suggest that the majority of workplace slip accidents occur as a result of wet contamination, it is well known that the presence of dry contaminants present a significant risk of pedestrian slipping. We have established, through simple observation, that dry contaminants can present a very real problem in certain industrial sectors, including food processing and production, laundries and construction.

This presentation will outline preliminary findings from ongoing research into the effects of dry contamination on pedestrian slip potential. We will study a number of popular portable coefficient of friction tests with a view to identifying which, if any, are capable of making accurate assessments of the effects of dry contaminants on a range of flooring types commonly encountered in industrial and commercial situations. We hope to be able to identify a useful site test and to recommend a testing regime for the use of that test.

In the latter stages of the study we propose to visit industrial sites in the food and non food sectors. This will allow us to evaluate the role of dry contaminants in real situations and to relate the results generated using our preferred test to incident records.

E1.2 Comparison of Coefficient of Friction Requirements During Gait to Tribometry Measurements: Evaluation of Shod and Barefoot Conditions at Various Walking Speeds—Powers CM, Burnfield JM, Brault JR, Flynn JE

Introduction: The Variable Incidence Tribometer (VIT) and the Portable Inclineable Articulated Strut Tribometer (PIAST) are frequently used to characterize walkway slipperiness, however the extent to which these devices reasonably emulate the dynamics of human gait has not been explored. The purpose of this study was to compare the utilized coefficient of friction (COF) during non-slip pedestrian gait to the COF obtained from the VIT and PIAST (as measured using a force plate).

Methods: Twenty healthy adults participated. Subjects walked barefoot and shod over a dry surface (smooth vinyl composition tile) at slow (57.3 m/min), medium (87.3 m/min) and fast (131.6 m/min) speeds with kinematic (VICON) and kinetic (AMTI force plate) data being recorded simultaneously. The VIT and PIAST tribometers were tested on the same force plate at angles equal to the average impact angle recorded across subjects for each condition tested.

Results: Utilized COF increased with higher walking speeds (slow, 0.22; medium, 0.24; fast, 0.26). When collapsed across walking speeds, the utilized COF during barefoot trials was greater than shod trials (0.25 vs. 0.22; $p=0.002$). At similar inclination angles (averaged across shoe conditions and walking speeds), peak COF values recorded for the VIT and PIAST were higher (30% and 50% respectively) than those recorded during walking trials.

Discussion: At comparable impact angles, both the PIAST and the VIT overestimated the utilized COF during gait. These findings suggest that the PIAST and the VIT do not imitate the dynamics of human gait at impact. We believe that the differences between the utilized COF during walking and the measured COF from the PIAST and VIT is most likely related to the fact that the tribometer test feet do not have the same vertical and horizontal accelerations of the pedestrian's lower leg at heel strike.

E1.3 Measuring the Exposure to Slipping Hazards: A Novel Test Device—Grönqvist R, Hirvonen M, Rajamäki E, Polvi P, Chang WR

A prototype test device and methods of measurement have been developed for determining the exposure to slipping hazards. The test device is suited for both field and laboratory use. It can be used to measure static, transitional kinetic, and steady-state kinetic friction properties between floor surfaces and shoe material samples. Two optional modes of operation, impact and non-impact testing, can be utilized.

The current prototype has two optional pneumatic test wheels, a complete rubber wheel with tread and another test wheel constituting of six separate slider sensor units. During the impact mode, the test wheel is rotated freely at a desired constant speed (0–0.6 m/s). The normal force is produced by inflating the wheel instantaneously. The applied contact time between slider and floor is monitored and the interfacial shear (friction) force is measured using a built-in torque transducer (Vibro-Meter TM208) and a measurement software (HP VEE 5.0). During the non-impact mode, the test wheel is operated from an initial, stationary position with respect to floor surface. A laptop computer equipped with a PC card (DT 7101) for analog-to-digital conversion of measurement data is used to compute static, transitional and steady-state kinetic friction indexes. Frictional variations over contact time, apparent normal pressure, and sliding velocity comprise the basic safety criteria for determining the exposure to slipping hazards. Hazard prediction models for various applications of the method are currently examined.

The project continues with test methods development, including selection of slider sensor materials for testing purposes and selection of reference floorings for calibration of the instrument. The remaining questions are: 1) how to simplify the device for actual field use, and 2) how to accurately control the normal force on different types of floor surfaces.

E1.4 Validating Slipmeters: Aspects of Conformity Between Test Feet and Floor Surfaces—Bowman R, Angelopoulos TA

A wide range of slipmeters has been developed to indicate the available slip resistance of pedestrian surface materials. The validation of such devices is largely based on measurements of the coefficient of friction (cof) using force platforms. While slipmeters may demonstrate high degrees of repeatability and low bias, they may also measure different slip resistance values for the same surface. One of many reasons may be poor conformity between the test foot and the floor surface.

Pedestrians are most likely to slip during heel strike. Contact area measurements at heel strike led to a 9 mm diameter test foot being used in the Tortus. Other slipmeters use larger feet: for example, ASTM C1028 uses a 76.2 mm square slider, and the Pendulum a 75 mm wide test foot.

Pendulum measurements were made on different coloured glazed (orange peel texture) 100 mm tiles from one product range. The wet cof varied from 0.23 to 0.57, but there was no correlation with R_{tm} roughness (range of 12.4 to 20.6 mm, 0.8 mm cut-off). A 75 mm wide paint roller was made from a rubber of similar hardness to Four S rubber. When paint was applied to the tiles, a lack of planarity was evident. When the tiles were tested according to SATRA test method PM 144 using

a 25 mm wide slider, the cof was consistently higher. The cof gave reasonable correlation with 60 degree gloss measurements.

While planarity deviations may affect a test result, they will not affect the friction that is available to the pedestrian. In order not to underestimate the available traction, it may be necessary to determine the degree of effective contact.

All slipmeters have potential limitations. When validating slipmeters a wide range of products should be evaluated and the results compared with subjective experiments using humans.

Session: E2.0

Title: Surveillance and Intervention Programs Targeting Injuries in the Construction Industry

Category: Special Session

Organized by T. J. Lentz, National Institute for Occupational Safety and Health

Moderator(s): T. J. Lentz

E2.1 Survey Shows Commitment to Safety by Large Construction Firms Produces Results—Hinze JW

In the fall of 1999, a nationwide study was conducted with the 400 largest construction firms in the United States. The survey addressed a variety of practices that are expected to produce good results in the area of safety. The survey also included questions on more novel approaches of achieving good safety performance results. The survey responses were compared with the reported injury frequency records to identify those practices that were associated with particularly good safety results. Several findings of interest were disclosed. First of all, the responding firms tended to have very good safety records, reporting an average injury frequency of about one-third of the industry average. Perhaps the most effective practices of the firms were in the area of training. Several variables on training were associated with good safety performance records. Several practices are clearly not mandated by regulations but were found to be associated with good safety records. Examples include the investigation of near misses, conducting worker safety perception surveys and considering past safety performance when making decisions on merit raises. While drug testing had been shown to significantly impact safety performance in past studies, this was no longer a finding, primarily because almost all firms have a fully implemented drug testing program in place. Interesting results were found that were related to safety incentives. Several additional findings of interest were also disclosed in the study.

E2.2 Evaluation of the OSHA Construction Accident Reduction Emphasis (CARE) Program in Florida—Johnston S

In Florida, in Fiscal Years 1996, 1997, and 1998, the number of construction fatalities increased from 50 to 58 to 65, respectively. The percentage of fatalities relating to construction compared to the total number of fatalities also increased. Due to this significant increase in construction fatalities, the Occupational Safety and Health Administration's (OSHA) Florida area offices developed and implemented the Construction Accident Reduction Emphasis (CARE) program. The mission of CARE is "to reduce construction accidents and fatalities in Florida by focusing resources on enforcement, partnership, and outreach." The program was officially implemented in March 1999.

To achieve the enforcement component, we are dramatically increasing the number of construction inspections by augmenting OSHA's Florida offices with compliance officers from other states. The additional personnel also allows OSHA to conduct a comprehensive inspection of all contractors on any site where a fatality occurs. OSHA is establishing partnerships with several organizations which will mentor contractors, particularly those small contractors with 25 or fewer employees, to improve their safety and health awareness and aid them in establishing effective safety and health programs.

To achieve the outreach component, OSHA is establishing alliances with the Florida Division of Labor, employers, organizations, advocacy groups and unions to provide training, information and assistance to employers and employees. OSHA is also holding informational meetings about the program, arranging construction training classes, supplying employers with computer disks containing 13 sample safety and health programs, developing and distributing safety posters and pocket cards, putting information about CARE on the Internet, developing and distributing information in Spanish, and encouraging news articles about the program by the media. Since the implementation of the CARE program, construction fatalities in Florida declined from 65 in Fiscal Year 1998 to 54 in 1999.

E2.3 Fall Protection Emphasis Within OSHA's Region V—Medlock R

In the construction industry, falls lead all other work-related causes of fatalities. Given this fact, coupled with two highly publicized construction accidents/fall fatalities that occurred in the Cleveland area, Mr. Medlock developed a Fall Hazard Emphasis Program designed to focus resources in addressing this major hazard. While the program began as a Cleveland initiative, it was expanded to cover all of Ohio and eventually all of OSHA's Region V. Due to the program's notoriety, similar local Fall Hazard Emphasis programs have emerged in

several locations throughout OSHA. One such emphasis program involves the construction of telecommunication towers.

The Fall Hazard Emphasis Program involved three initial phases which featured stronger enforcement and a better inspection targeting system. Along with increased enforcement, an outreach program was provided to contractors, associations, and labor, that provided education in best work practices and fall protection methods. Further, the Agency also developed internal fall protection coordinators/specialists within each Area Office. This not only enhanced OSHA's expertise, but also provided a compliance assistance resource to interested stakeholders.

The presentation will include the program's results with regards to fatality trends, inspection response times, violation/fall hazards corrected, training successes and how the program established increased respect for OSHA in the construction industry. It will advise as to how certain initiatives within the program were successful in getting companies to require fall protection at heights less than required by the OSHA standards.

E2.4 An Unconventional Surveillance Tool for Tracking Construction Projects in the State of Illinois—Broderick T

The construction industry presents challenges for occupational safety and health professionals conducting research or designing and implementing safety programs. Construction projects are often of short duration and located in remote areas. Regulators find the industry difficult to examine for the same reasons. OSHA uses data supplied by the University of Tennessee (UT) to schedule inspections of construction sites. Supplied to UT by a private sector vendor, the data are at times outdated or erroneous and the projects may have been canceled or may have already been completed. Compliance officers waste valuable time when they drive around attempting to locate specific projects, only to find completed work or vacant land.

A project tracking system in Illinois provides superior accuracy and has the capability to capture extensive information on both publicly (48%) and privately (52%) funded projects. Currently, users of the system have access to information on over 97,000 projects in Illinois and the Northern portions of Indiana and Iowa. Additionally, users of the system can access over 65,000 company directories, for detailed information about each firm.

The contractor files contain histories of projects that have been bid or have been awarded. A resume of each contractor can be produced. The project files describe the scope of work to be performed, whether the job will be union or open shop, estimated cost of construction, anticipated start and end dates, exact location of the job, and key information about

contacts at the site. Information about subcontractors working at or proposed for the project can be found, as well.

This system was initially developed to assist union contractors and building trades unions to identify prospective projects well in advance of contractor selection. This enabled early marketing efforts to target owners with information about the virtues of "building union". Recently, OSHA's Region V office in Chicago initiated a subscription to examine the system's viability as a surveillance tool for locating construction sites. The existing targeting system at University of Tennessee is reportedly ineffective at locating small and short duration projects, such as the highly hazardous tower erection sites. Currently OSHA is field-testing the system and the presenter will provide the latest information on its viability for compliance purposes.

A system with this degree of accuracy may eventually have other uses for health and safety professionals seeking information or conducting intervention work from/with these highly mobile worksites and their similarly mobile workers.

Session: E3.0

Title: Young Worker Injuries: Innovative Interventions and Evaluation Challenges

Category: Special Session

Organized by the NORA Special Populations at Risk and Intervention Effectiveness Research Teams

Moderator(s): Dawn Castillo

E3.1 Injuries to Young Workers: An Overview—Davis L

Millions of youth in the United States are employed each year. While work can have important benefits, it also imposes health and safety risks. Each year nearly 70 youth die as a result of work-related injuries and tens of thousands are injured. This presentation will provide an overview of youth employment in the United States and the descriptive epidemiology of both fatal and non-fatal occupational injuries among young workers. Patterns by age, gender, and industry will be described and the available information on comparative injury rates for young and adult workers will be discussed. Risk factors specific to young workers that need to be taken into account in developing intervention activities will be also be addressed. These include, for example, the developmental characteristics of youth and inexperience. Some of the outstanding research questions will also be highlighted.

E3.2 Expanded Opportunities for Prevention of Young Worker Injuries—Sinclair, RC

There is little disagreement that there is a need for information and education about young worker injuries. Youth, parents, employers, teachers, health departments, labor departments, and health care providers tend to be surprisingly uninformed about the hazards youth face at work and what can be done

to prevent injuries. In 1995, NIOSH funded three community-based health education projects to learn how to increase prevention knowledge. Those projects yielded a number of lessons that were collected in a resource guide for community leaders on how to intervene at the community level. In spite of those lessons, there was much more to be learned. In particular, methods to institutionalize education about young worker issues in communities were still underdeveloped. Consequently, in 1998 and 1999, new projects were funded to expand knowledge about introducing and sustaining interest in young worker issues among communities. Each project looks at a different aspect of community interventions and brings different expertise to bear. Each project also uses different evaluation methods. One project is conducting a rigorous evaluation of curriculum in schools in Minnesota. Another project is working in contrasting ethnic communities in Los Angeles to learn about different attitudes toward young worker injuries. The third project is facilitating state-level teams in New England who are conducting small health education projects in selected communities. These projects are providing further lessons about how to intervene, but they also provide a spectrum of evaluation challenges. They attempt to address different levels of social influence, so they must be evaluated in different ways. The results of these projects may inform the progress of community intervention evaluations.

E3.3 Coordinated State Efforts to Prevent Young Worker Injuries—Miara CH

In 1998, the National Institute for Occupational Safety and Health provided a three-year grant to the Education Development Center to form the Northeast Young Worker Resource Center (NYWRC). This regional resource center serves Massachusetts, Maine, New Hampshire, Connecticut, Rhode Island, Vermont, New York, and New Jersey. With assistance from the NYWRC, teams have formed in five of the states, which include representatives from state departments of health, labor, and education. Drawing on the experiences and materials already developed by three NIOSH community-based grantees, these teams have undertaken a variety of activities to address the safety of young workers at the state level.

The state teams' accomplishments demonstrate the value of building collaborations among various disciplines. This presentation will describe ways young worker safety is being integrated into various institutions and programs in the state and policy changes are being implemented. Activities range from the department of education sending copies of a health department-developed young worker safety brochure to all schools in the state; a state-level training team that provides workshops for job trainers, teachers, and local health professionals; advocacy for changes to the work permit system; presentations for employers at a statewide conference; improvements in collection of data on young

worker injuries; and integration of occupational safety into the state's coordinated school health program.

The teams have also selected one community in their state in which to pilot an educational intervention. This presentation will also highlight several examples of ways that the state teams and the community projects are building on each others' work.

E3.4 Community-Based Efforts to Prevent Young Worker Injuries in an Ethnic Community—Guihama JB

Recently, an important National Research Council/IOM report, "Protecting Youth At Work," acknowledged the lack of information and research about the work experiences of immigrant and minority youth. This presentation will share experiences and lessons learned from a community- and school-based young worker education project that works with youth of color in Los Angeles.

The focus of this presentation will be to provide an overview of a project that combines school-based education and skills building revolving around the issues of young worker safety and health, peer education and youth leadership with community-based opportunities for youth-led outreach and education. In addition, this presentation will describe the experiences of minority youth who are involved in this young worker intervention project.

The evaluation of this intervention project will also be briefly discussed. This evaluation will assess the role of school-based curricula and peer education about job safety and worker rights in reaching students and the broader community. This evaluation involves both qualitative and quantitative methods to answer the following questions:

- How effective is a two week 9th grade curriculum unit at raising students' awareness of occupational safety and health?
- What is the impact of a semester-long curriculum on educating 11th/12th grade students about worker rights and developing peer education and leadership skills?
- What is the role of students in reaching their peers and parents with information about occupational safety and health and worker rights?

The preliminary results will be discussed in the context of reaching the largely underserved population of immigrant workers and their families with information about occupational safety and health and worker rights.

E3.5 School-based Efforts to Prevent Young Worker Injuries—Hillmer TG

Purpose: Inclusion of a work health and safety curriculum into existing school curricula has the potential to reach a

broad group of adolescents and impact their work-safety behaviors. The purpose of this project was to develop, implement and evaluate a school-based occupational health and safety curriculum.

Methods: The curriculum “Work Safe Work Smart” was developed by a curriculum development team that included teaching and public health professionals. The curriculum attempts to promote changes in students that are predictive of adopting safe work-related behavior.

In January and February 2000, the curriculum was taught in required classes to all 9th and 10th grade students in five rural Minnesota schools. Six schools within the same geographic region served as controls. Pretests were administered to 9th and 10th graders in the eleven participating schools prior to implementation of “Work Safe Work Smart”. Post-tests were given approximately two weeks following completion of the curriculum, and again six months later. Process evaluation in intervention schools included teacher checklist, classroom observer checklists, and teacher and student interviews.

Results: The curriculum was successfully incorporated into existing courses, such as health, social studies and career exploration during the study period. Information from implementation teachers and administrators further elucidated factors involved in institutionalization of the topic into the school curricula. Data collected from student interviews and the outcome evaluation will provide insight into the efficacy of “Work Safe Work Smart” to produce change in predictors of students’ work-related safety behaviors.

Conclusion: These data will provide information on incorporating occupational safety and health curricula into existing schools curricula. It will also provide insight into the impact teaching “Work Safe Work Smart” has on students.

Session: E4.0

Title: Fatality Assessment and Control Evaluation (FACE)

Category: Injury Surveillance

Moderator(s): William Hetzler

E4.1 Identification and Evaluation of Injury Circumstances Contributing to Crane-related Occupational Fatality—Moore PH, Pratt SG

Introduction: Cranes are used in a broad range of industrial settings to hoist and transport materials. Mobile cranes used in construction, mining, and transportation move between locations, often while carrying a load. Tower cranes are used at urban building construction sites where limited maneuvering room is available. Overhead traveling cranes are a necessity in heavy manufacturing, railroad and seaport operations. This study identified injury risks for workers

operating or working near cranes and developed recommendations for injury prevention.

Methods: The Census of Fatal Occupational Injuries (CFOI) was used to identify crane-related fatalities from 1992 to 1997. Results of 73 field investigations conducted by NIOSH’s Fatality Assessment and Control Evaluation (FACE) program between 1982 and 1999 were evaluated to identify circumstances which contributed to each type of event.

Results: The CFOI identified 479 occupational fatalities between 1992 and 1997 for which a crane was the primary or secondary source of injury. Injury events included contact with objects and equipment (41%), falls to lower level (13%), contact with electric current (24%), and transportation incidents (10%). Injury circumstances of the fatalities investigated through FACE were 36 power-line contacts, 11 crane tip-overs, 11 rigging failures, 9 falls from cranes or suspended work platforms, 3 caught by or struck by crane components, and 2 incidents where the crane was in transport.

Conclusion: Crane fatalities can be prevented by implementation of safe work procedures including maintaining safe clearance between cranes and overhead power lines, operating within manufacturer’s recommended capacities, using load monitoring instruments, and maintaining safe clearance between workers on foot and cranes.

E4.2 Work-related Fatalities in West Virginia: A Summary of Surveillance, Investigation, and Prevention Activities - July 1996 Through December 1999—Helmkamp JC, Lundstrom WJ, Williams JM

Background: From 1990 through 1995, West Virginia experienced a work-related death (WRD) rate of 8.9 deaths per 100,000 workers — the fifth highest rate among all states and twice the national rate. As a result, the West Virginia Fatality Assessment and Control Evaluation (WV FACE) program was established in 1996 to identify all WRDs, define work situations at high risk for fatal injury, investigate selected causes, and formulate and disseminate prevention strategies.

Methods: WRD surveillance and investigation data are used to describe trends and rates and identify hazardous conditions, unsafe work practices, and management-leadership problems through the use of the traditional epidemiologic model and the Haddon temporal matrix. Prevention strategies are developed and disseminated to audiences.

Results: From July 1996 through December 1999, 191 persons died from traumatic work-related injuries. The WRD rate was 7.6 per 100,000 compared to 4.7 for the U.S. (1996-98). Ninety-four percent of the victims were male and all Caucasian. Mean age at death was 43 years. Leading external causes of death included motor vehicle (48), struck by object (38), machinery-

related (24), fall from elevation (15), and homicide (10). WRDs occurred most often in the transportation/public utilities (37; truckers - 22), manufacturing (32; loggers - 24), mining (28), construction (26), and services (25) industry sectors. Nineteen on-site investigations were conducted (10 logging, 5 machine-related, and 4 fall from elevation); no company safety programs, inadequate training, lack of oversight were consistently noted. Summary reports were prepared for employers, cause-specific Fatal Incident Alerts written for workers, and an article published in the peer-review literature.

Conclusions: The WV FACE program has contributed to a better understanding of fatal traumatic occupational injuries within the state and the importance of coordinated efforts by employees, employers, and safety and public health professionals to reduce the frequency and societal impact of these injuries.

E4.3 Functional Limitations Leading to Fatal Work Injuries of Farmers in Wisconsin—Tierney JM, Hanrahan LP

The WI FACE Program recorded 914 traumatic occupational fatalities from October 1, 1991 through September 30, 1999. Sixty-nine in-depth investigation reports were completed, including thirty-one cases of farm fatalities. In seven cases of farm fatalities, investigators concluded that the victims had pre-existing functional limitations that contributed to the fatal injury. Pre-existing physical conditions may prevent farmers from using equipment in the way it was intended, causing the farmers to circumvent safety features and methods. Examples include not being able to step up or climb onto a tractor mounting platform, lacking leg strength to depress foot levers, and not being able to dismount the tractor seat platform due to decreased flexibility of knee joints. Case examples with risk factors are presented, with recommendations for prevention.

The Fatality Assessment and Control Evaluation (FACE) Program was designed by the National Institute for Occupational Safety and Health (NIOSH) to assist employers in preventing occupational injuries by identifying work situations at high risk for injury, and formulating and disseminating prevention strategies to those who can intervene in the workplace. The State of Wisconsin has a cooperative agreement with NIOSH to conduct surveillance, investigation and intervention activities using the NIOSH FACE model. All traumatic occupational fatalities are reported to NIOSH. In-depth investigations are done of selected cases of machine-related incidents, youth fatalities, and fatalities in the road construction work-zone. Injury circumstances and risk factors are identified and recommendations for prevention are written and disseminated.

E4.4 The Washington State Fatality Assessment and Control Evaluation (FACE) Program: High Risk Populations—Cohen MA, Sjostrom T, Clark R

The goal of the State of Washington's NIOSH funded Fatality Assessment and Control Evaluation (FACE) Program is the reduction of work-related traumatic injuries through fatality surveillance, field investigation of targeted incidents, and development and dissemination of intervention strategies to those who can influence safety in the work place. The Washington FACE surveillance system has identified a number of worker populations with elevated risk for traumatic fatality. This study summarizes the hazards for injury for these populations. Construction workers, agricultural workers, loggers and log haulers, minority workers, and truck drivers all have high risks of death while on the job, accounting for approximately 55% of the 194 work-related fatalities in Washington State in 1998 and 1999. Construction workers account for 17%, truckers 16%, minorities 15% (10% Hispanic and 5% non-white), logging-related incidents 11%, and agricultural workers 11%. Populations such as construction workers are exposed to hazards that one would generally expect, while the hazard exposure for others, such as agricultural workers is somewhat surprising. As might be expected, falls from elevation (45%) were the leading incident type occurring in construction, and truck drivers most often die in motor vehicle collisions (84%). However, drowning accounted for 24% of the agriculture-related incidents, while 24% were motor vehicle-related, and 14% were homicides. Only 14% of the agriculture-related incidents were machinery-related and 10% were tractor rollovers. Minorities are primarily involved in motor vehicle-related incidents (24%), but 21% were victims of homicide. This population accounts for 46% of all work-related homicides. Twenty-three percent of the logging-related incidents involved being struck by falling objects, while 36% were motor vehicle-related. Only with a better understanding of the circumstances surrounding acute trauma fatalities will we be able to prevent future incidents.

Session: E5.0

Title: Injury Risk Factors

Category: Injury Risk Factors

Moderator(s): Christine Branche

E5.1 Race Modifies Other Risk Factors for Knee-related Disability Among Women in the U.S. Army—Sulsky S, Mundt K, Bigelow C, Amoroso P

Objective: To identify occupational and sociodemographic determinants of knee-related disability discharge among women enlisted in the U.S. Army.

Methods: A case-control study of 692 women (n=232 nonwhite) discharged with knee-related disability and 2,080 (n=1,053 nonwhite) density-sampled controls, nested within the cohort of active duty enlisted women, 1980-1997. We

used multiple logistic regression models to identify determinants of disability discharge, and stratified analyses to explore effect modification.

Results: In multivariable analyses, non-white women had half the risk of disability compared to whites (odds ratio (OR)=0.5, 95% CI (CI): 0.41, 0.60). Age, marital status, pay grade, and job category were also predictors of disability. In stratified analyses, ORs increased monotonically from 0.68 to 2.66 with increasing quintiles of age for white women (range: 17-60 years). Among non-whites, ORs stayed at 1.1 through the third, doubled in the fourth and increased to 2.4 in the fifth relative to the first quintile of age. Risk of disability was lower for married versus non-married women of both races. For both races, women in the highest pay grades had the lowest ORs vs. women in the lower grades (OR=0.25, CI: 0.12, 0.50 for whites and OR=0.14, CI: 0.06, 0.33 for nonwhites). Relative to support/administration, most job categories showed small increases in risk. ORs for white women were lower than ORs for nonwhite women for three of eight, and higher for two of eight categories.

Conclusions: For Army enlisted women, sociodemographic characteristics were stronger determinants of knee-related disability discharge than work exposures. Interactions between race and occupation suggest certain subgroups in the Army are at higher risk of disability than others; further understanding of these patterns may suggest effective interventions. To elucidate the role, if any, of job characteristics and/or work exposures in the development of knee-related disability, future research should be restricted to specific demographic subgroups.

E5.2 Toward a Typology of Dynamic and Hazardous Work Environments—Scharf T, Vaught C, Kidd P, Steiner L, Kowalski K, Wiehagen B, Cole H

Mining, fishing, logging, farming, construction, and transport: by many measures, these are the most hazardous industries in the U.S. Is there an underlying consistency to the fatality records? Or are the causes of occupational fatalities so unique to each industry that no common features can be determined? On the one hand, we see the same jobs ranking highest on fatalities year after year - suggesting a consistent pattern. On the other hand, the causes of these fatalities are quite specific to each of the jobs, e.g. falls from heights (construction), tractor overturns (agriculture), roof collapse (mining), etc. - suggesting unrelated mechanisms of injury.

We suggest that the common feature of these jobs is that the work environments are under constant change. The central thesis of this paper is that the requirement to continually adapt and respond to a dynamic and hazardous work environment places workers in these jobs at highest risk, regardless of the specifics of the hazards. What our observations suggest is that workers react in similar ways to

changing hazardous situations, even though the specific hazards may be quite different.

Translated into a research hypothesis, what are the common components of change that can be identified across different dynamic and hazardous work environments? More specifically, since the hazards are very different, are there common qualities about the dynamic nature of the hazards that can be identified? Two questions are implied: 1) what makes an environment hazardous, and 2) what makes a work environment dynamic?

These questions are examined and discussed. A preliminary typology of dynamic and hazardous work environments is proposed, and the workload pressures on the workers are considered. The long-term goal of this effort is to improve the safety and efficacy of organizational-level work practices in dynamic and hazardous work environments.

E5.3 Indicators of Lift Readiness and Lift Posture in Patients With Low Back Pain—Dionne CP, Smith SS

The purposes of this study were to (a) determine clinical indicators for initiation of lifting by patients with low back pain (LBP); (b) determine the greatest lift force exerted by patients in three lift postures, comparing lift capacities with those of healthy subjects.

From a consecutive sample of 40 patients with LBP, 35 patients (18 men [aged X = 36.7 years, SD= 7.5], 17 women [aged X = 39.3 years, SD = 7.8]) passed the screening criteria and were randomly assigned to one of four groups in which repeated movements testing (RM) was compared separately and in combination with trunk extensor muscle endurance, sitting, and all protocols. Thirty-one patients confirmed lift readiness with a self-selected lift, then tested in three lift positions (self-selected, lordotic, and kyphotic).

To compare the four sets of lift criteria, a Chi-square test for independent samples was used. To determine predictive clinical indicators of lift readiness, positive predictive values were calculated. A repeated measures MANOVA was used to determine differences in lift force between patients and healthy subjects and among lift postures in patients.

No difference was found among the four sets of lift criteria used to confirm lift readiness. All four sets lift readiness criteria were positively predictive (PPV 3 75%). Thirty of 31 patients lifted, and successfully managed their symptoms. Isometric lift force capacity differed between healthy subjects and patients, but did not differ between lordotic and self-selected lift postures among patients.

RM testing may be the only criterion necessary because RM was as predictive as the other sets of lift readiness criteria.

Patients with LBP may lift in either lordotic or self-selected postures.

E5.4 Fatal and Nonfatal Injuries Among Public Sector Employees—Windau JA, Drudi D

Almost 5,000 government workers lost their lives in the line of duty between 1992-98. About half of these deaths were to workers involved in protecting the public safety, such as police officers, firefighters, and military personnel. Although government workers in general have lower fatality rates than private sector workers, public safety workers are at increased risk of suffering a fatal injury at work. Other public sector industries with relatively large numbers of fatal injuries include health, education, and social services, highway construction, and public utilities.

This presentation will summarize data from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI). Working in collaboration with State agencies, the CFOI program uses diverse data sources to identify, verify, and profile fatal work injuries. In addition to the circumstances surrounding the fatal event, the presentation will discuss the level of government (Federal, State, Local), industry, occupation, and demographic characteristics of the fatally injured worker. Data on nonfatal injuries from the 25 States that provide public sector data in the Bureau's Survey of Occupational Injuries and Illnesses will also be summarized.

E5.5 Nonfatal Occupational Injuries Among African-American Women by Industry—Chen GX, Hendricks KJ

A previous study suggested that African-American women may have a higher rate of work-related injury that requires treatment in emergency department (EDs) and a higher proportion of employment in the healthcare industry compared to white women and women of other races. This study examined this type of injury by industry among African-American women using the National Electronic Injury Surveillance System, a national surveillance system for nonfatal work-related injuries treated in EDs in the U.S. Injury rates were calculated based on employment data from the Current Population Survey. In 1996, African-American women, aged 16 or older, were treated in U.S. EDs for an estimated 141,427 nonfatal work-related injuries (2.3/100 full-time equivalents (FTEs)). Of these injuries, 38% occurred in the healthcare industry, with retail trade accounting for 14% and manufacturing accounting for 12%. The healthcare industry experienced the highest injury rate (4.5/100 FTEs), followed by construction (2.9/100 FTEs) and retail trade (2.4/100 FTEs). Injury patterns varied by industry in terms of source and event. For example, in healthcare, the leading injury source involved interactions with patients (i.e., lifting/moving patients) and the leading injury event was bodily reactions and exertions. Whereas, the leading source of injury for retail trade involved falls to the floor and the leading injury event

was struck by or against objects. This study is consistent with the previous study and demonstrates that the higher injury rate among African-American women is due, at least in part, to the higher proportion of employment in the healthcare industry, an industry with the highest injury rate. The different injury patterns by industry underscores the need for targeted research and effective prevention efforts in high-risk industries.

E5.6 Occupational Fatalities Among Emergency Medical Services (EMS) Providers in the US: A Comprehensive Review of the 1992 to 1997 Data From CFOI, FARS and the National EMS Memorial Service—Maguire BJ, Hunting KL

Introduction: Emergency medical technicians and paramedics respond to automobile collisions, shootings, medical emergencies, hazardous material incidents and large-scale disasters. These emergency medical services (EMS) personnel are exposed to a wide variety of occupational hazards including: ambulance collisions, assaults, infectious disease, hearing loss, lower back injury, hazardous materials exposure, stress, extended work hours, and exposure to temperature extremes and shift rotation.

Objective: To determine the risk of occupational fatality among EMS personnel.

Design: Analysis of data for 1992 to 1997 from the Census of Fatal Occupational Injuries, the Fatal Accident Reporting System and the National EMS Memorial Service.

Result: 143 EMS occupational fatalities were recorded. Almost three quarters of the fatalities occurred in collisions. Ten of the decedents were struck by a moving vehicle. Nineteen died while working in the patient compartment. Ten of the fatalities occurred secondary to assault. Three individuals drowned during rescue attempts.

Conclusions: Improved driver training programs, ambulance engineering changes, scene safety training and changes to personnel scheduling policies may all be needed in order to reduce the fatality rate secondary to collisions. Additional research is needed to develop and evaluate other interventions to reduce the fatality rate. A national database must be established to identify risks and track changes secondary to planned interventions.

Session: E6.0

Title: Social/Economic Impacts II

Category: Social/Economic Impacts II

Moderator(s): Elyce A. Biddle

E6.1 The Economic and Social Consequences of Injury at Sand and Gravel Operations—Camm TW, Ferch S, Boldt CMK

Total economic and social costs of workplace injuries in the sand and gravel industry are being evaluated in this study. The goal is to increase our understanding of the impact of work-related injuries to workers, co-workers, and families. This will provide a reliable basis for targeting and evaluating the effectiveness of investments in prevention for industry safety and health programs.

Injury costs involve more than just direct costs to a mining company or its insurer, and sometimes, indirect costs will exceed direct costs. Direct costs include medical, legal and administrative, workers' compensation administration, and property damage. Indirect costs include lost earnings, lost fringe benefits, lost home production, employer costs of retraining and re-staffing, coworker costs of lost productivity, and time delays.

A cooperating sand and gravel operation was selected to evaluate the questions relevant to measuring direct and indirect costs before applying these questions to a site where an actual accident occurred. This process will allow us the interpretation of measurements and responses without the emotional stresses involved in an actual injury. This case study approach should provide a richness and depth to the data not always obtainable in a statistical study that relies on large, aggregated databases. Upon completion of the study, the methodology and cost sources should be well established to use in subsequent studies.

E6.2 Earnings Losses From Permanent Disability at Private Self-Insured Employers in California—Reville RT

Employers that self-insure for workers' compensation face incentives to return injured workers to work sooner, and since they are larger, often have more opportunities for modified work. We examine the consequences of a disabling workplace injury for workers in 1993-95 at 66 self-insured employers in California. Using data on permanent disability claims provided by the firms linked to longitudinal earnings data before and after the injury from the state of California, we estimate the earnings losses associated with a permanent disability, and examine the return-to-work patterns of permanent disability claimants. We find significant earnings losses for PD claimants at these firms — more than 20 percent over the five years after injury. We then compare the experiences of workers at self-insured firms to workers at insured firms and find lower proportional losses at self-insured

firms, but also slightly lower replacement rates. Both findings are largely driven by the higher earnings for all workers at self-insured firms. We also find better return to work (sooner and more likely to be employed at the at-injury employer) at self-insured firms. However, when controlling for preinjury earnings and firm size, differences in earnings losses between workers injured at self-insured and insured firms tend to disappear.

E6.3 The Cost and Consequences of Work-Related Assaults—McGovern P, Kochevar L, Lohman W, Zaidman B, Gerberich S, Nyman J, Findorff M

Objective: To describe the long-term productivity costs of work-related physical assaults.

Methods: The human capital approach was used to describe the long-term costs of work-related assaults using all incidents of non-fatal assaults resulting in indemnity payments that were identified from the Minnesota Department of Labor and Industry (DLI) Workers' Compensation system in 1992. Medical expenditures were obtained from insurers, and data on lost wages, legal fees and permanency ratings were collected from DLI records. Insurance administrative expenses were estimated. Lost fringes and household production losses were imputed. The present value of past losses from 1992-1995, and future losses, for cases open in 1996 were estimated. Cost estimates were adjusted to 1999 dollar values using the Consumer Price Index. A pilot study, employing a case study methodology, was also conducted to describe individuals' perspectives on the social costs of assault.

Results: The total costs for 344 non-fatal work-related assaults were estimated at \$6,232,689 (1999 dollars). Calculation of injury incidence and average costs per case and per employee identified populations with an elevated risk of assault. An analysis by industry revealed an elevated risk for workers employed in justice and safety (incidence: 198/100,000; \$20,387 per case; \$40 per employee), social service (incidence: 127/100,000; \$25,638 per case; \$32 per employee) and health care (incidence: 76/100,000; \$13,976 per case; \$11 per employee). Case study results suggest that four years post-assault individuals' health and quality of life were significantly affected and resulted in job changes, chronic pain, changes in functional status and depression.

Conclusions: Workers most at risk were lower wage workers. Identified subgroups warrant attention for risk factor identification and prevention efforts. Cost estimates suggest the value of risk management interventions, and can inform the social policy debate on the impact of workplace violence.

E6.4 Followup Study of Musculoskeletal Injuries Among Construction Workers—Hunting KL, Welch LS, Hsu L

To evaluate the contribution of acute trauma to chronic musculoskeletal symptoms, we conducted a followup study of 143 construction workers treated in an emergency department for acute soft-tissue musculoskeletal injuries. Telephone interviews were conducted several weeks, 1 year, and 2 years after the injury. For comparison, we interviewed 213 trade- and age-matched workers who were treated for other types of injuries. The initial interview focused on symptoms at the location of the musculoskeletal injury (the “index location”), as well as recovery patterns, light duty, lost worktime, injury history, and job tasks.

The WMD injuries, though acute in nature, were often related to ergonomic risk factors such as lifting heavy materials or exerting force from awkward working positions. Workers with musculoskeletal injuries were more likely than comparison workers to have previously experienced a serious acute injury to the index body location (27% versus 17%). This difference was seen for all body regions. Only 13% of the workers with musculoskeletal injuries were able to return to work without lost days or light duty, versus 28% of the workers with other injuries.

One-year followup interviews - focusing on health, work, and socioeconomic consequences of the injury - were completed for 201 (56%) of baseline participants. One year after the injury, 13% of the workers with musculoskeletal injuries were not working because of their original injury or a re-injury. In contrast, none of the workers in the comparison group were not working because of their injuries. We will describe symptoms one year after the injury, probability of re-injury, changes in work practices, injury-related functional limitations, and changes in perception of job risks and financial security for these two groups of injured workers. We will also compare outcomes for individuals with and without a history of previous injury to the index body location.

E6.5 Detection, Disease Management, and Compensation: Health and Economic Outcomes of Occupational Carpal Tunnel Syndrome Among Garment Workers in New York City—Fahs MC, Kontos NJ, Herbert R, Plattus R, Job L, Alcalá M, Berliner H

This Robert Wood Johnson Foundation funded project evaluates an innovative health care delivery and financing intervention with the Union of Needletrades, Industrial and Textile Employees (UNITE). In collaboration with Mount Sinai School of Medicine, workers in NYC’s garment industry received expedited access to timely treatment for occupational carpal tunnel syndrome. The intervention circumvented the greater than 400-day average delay in Workers’ Compensation (WC) approval. Results are presented from a combined retrospective/prospective

analysis of this largely immigrant population. These low-wage workers are predominantly older, female, and non-white (90% Latino, 10% Asian) and non-English speaking. The majority are sewing machine operators (76%) with an average tenure of 20 years in the garment industry. Clinical and functional status at diagnosis, as well as workers’ perceptions of the program’s impact on health outcomes, quality of life, work status, and quality of care are analyzed. Results show that workers have suffered severe financial hardships as a result of their occupationally-related condition (46% used up their savings, 29% lost their medical insurance due to their injury). Study participants continue to have substantial impairment 2-3 years after filing their WC claim (mean SF-12 score, physical functioning is 25, $p < .0001$ compared to general US population score of 50). Most were no longer able to work at diagnosis and many never returned to work (83%). Comparative results from a sample of non-immigrant computer users are presented, documenting large social and economic disparities between these two high-risk groups of workers filing WC claims. Policy implications are discussed.

E6.6 The Concentration of Workers’ Compensation Expenditures in a Construction Workforce: Implications for Cost Containment—Bondy J, Glazner JE

Objective: To examine the distribution of workers’ compensation (WC) expenditures in a construction workforce that spent over 31 million person-hours building Denver International Airport between 1991 and 1994.

Methods: We used a centralized database containing all claims and payroll for the project-wide insurance plan. An on-site clinic and designated medical provider system for all contractors addressed the problems of underreporting work-related injury and illness and variation in medical practice. Medical and indemnity payments for the project’s 4,634 claims represented total lifetime payments and were adjusted to 1994 dollars.

Results: Concentration of WC expenditures exceeded that of U.S. health care expenditures: the top 1% of claims accounted for 34% of the \$42.7 million expenditures at DIA; the top 5% accounted for 69% of expenditures. (Indemnity payments accounted for the great majority of expenditures among the top 5% of claims.) Corresponding percentages for health-care expenditures were 30% and 58% in 1987.1 Of claims for injuries in 1991, before the project’s safety program was fully operational, 10.8% were in the top 5% of claims, versus 4.1% in subsequent years.

Discussion: These findings suggest that cost containment efforts focusing on the average injured worker—whether by prudent use of medical services, mandating medical provider adherence to practice guidelines, or requiring employer accommodation and return-to-work programs—will not target the sources of greatest expenditure. The alternative of

reducing disability payments to severely injured workers, however, would be an unpalatable choice for most Americans. The apparent effect of the project's broad safety program in reducing the proportion of expensive claims suggests that prevention efforts can reduce not only rates, but severity, of injury. Prevention may have greater promise for reducing costs than would focusing on medical services or return-to-work programs.

Session: F1.0

Title: Biomechanics of Slips and Falls

Category: Special Session

Organized by Raoul Gronqvist, Liberty Mutual Research Center for Safety and Health

Moderator(s): Raoul Gronqvist

F1.1 Adjustments in Gait Biomechanics on Potentially Slippery Floors—Cham R, Redfern MS

In the workplace, unexpected slippery surfaces are often the cause of fall accidents. Findings of well-controlled gait experiments on slippery surfaces have been used to investigate slip and fall biomechanics, design "safe" foot/floor interfaces and develop slip resistance testers. However, in laboratory settings, it is quite challenging to reproduce the unexpected nature of slipping accidents. The purpose of this study was to quantify the changes in gait biomechanics when subjects anticipate a possible slippery environment and investigate whether gait returns to baseline characteristics after a contaminated trial. Foot forces and body dynamics of sixteen subjects walking on three dry surfaces (vinyl, smooth painted and rough painted plywood) of varying inclination (level, 5° and 10°) were recorded at 350 Hz. Gait biomechanics were compared among baseline trials (dry conditions), anticipation dry trials with a possibility of contaminant conditions (water, soap or oil) and recovery trials (recorded after a contaminated trial). Subjects were asked to walk as naturally as possible throughout testing even though there may be a contaminant condition. A within-subject repeated measures ANOVA of the trial type (baseline, anticipation, recovery) influence and flooring effect on specific gait parameters was performed within each ramp angle condition. Anticipation trials produced peak required coefficient of friction values (RCOF) that were on average 16 to 33% significantly lower than those collected during baseline trials. During recovery trials, peak RCOFs did not return to baseline values (5-12% lower). Thus, subjects reduce slip probability on potentially contaminated floors. This reduction was achieved by adopting postural and temporal gait changes resulting in ground reaction forces decreases. In addition, as a result of these adaptations, anticipation of slippery surfaces led to significant reductions in lower extremity joint torques (particularly at the knee and hip), thus decreasing the strength requirements of walking.

Acknowledgments: Supported by NIOSH (5 R03 OH03621-02).

F1.2 Safety on Stairs: Biomechanical and Visual Factors—Cavanagh PR, Owens DA, Startzell JK, Christina KA, Okita N, and Milner CE

Locomotion on stairs is among the most challenging and hazardous activities of daily living for elderly individuals. The demands that stairs place on the musculoskeletal and cardiovascular systems are compounded by the need for input from the somatosensory, visual, and vestibular systems at various stages in the task. Many of these collaborating systems deteriorate with aging, thus increasing the difficulty and risk of failure in a task that inherently involves exposure to significant danger. The task itself varies in its degree of challenge depending on many structural and environmental factors which are outside the control of the stair user. In this paper we will present a summary of results from several studies using the instrumented stair laboratory at Penn State. We will examine the interaction of the foot with the contact stair, clearance of the swinging foot over the stair, and the dependence of these measures on vision. We will also present preliminary data on stair descent strategies in individuals with osteoarthritis of the knee joint.

In normal visual conditions, our results indicate that, in healthy individuals, there is a progressive refinement of the stair clearance height during descent. Without vision, clearance is increased in magnitude and does not change during descent. Foot placement is also more conservative on all stairs. The ground reaction force profiles during descent are quite different when compared to overground walking, and demonstrate distinct differences depending on stair location. The frictional requirements during descent are similar to those found in level walking at the touchdown phase, but are typically less than level walking during the push-off phase. Greater frictional demands are present during the transition phase of stair descent, when compared to the mid-stair region. Joint disease increases the difficulty of stair descent, and often results in a "step-to" rather than "step-over-step" gait pattern.

F1.3 Slip Potentials During Load Carrying—Redfern MS, Cham R

The peak required coefficient of friction (RCOF), defined as the peak ratio of shear to normal foot forces, has been used to assess the frictional requirements of walking and related to slip potential. Although carrying loads is a common industrial task, few studies have investigated the effect of external loads on gait biomechanics relevant to slips and falls. The purpose of this study was to examine the effect of carrying (2-handed method) on gait biomechanics relevant to slips/falls on both level and inclined surfaces. The experimental conditions included three ramp angles (0°, 5°, 10°) and three load carrying levels (0, 2.3 kg, 6.8 kg). Both body motion and foot forces were recorded at 350 Hz. The relationship between load carrying and gait biomechanics

was investigated using a within-subject repeated measures ANOVA on specific gait parameters within each ramp angle condition, with the independent variable being load level. Statistically significant increases in the normal forces (partly due to the load's weight) and rate of normal loading (higher angular foot velocity, earlier peak of normal force) were associated with load carrying, which interestingly did not affect shear forces. This, in turn, resulted in small but significant decreases in the peak RCOF. More controlled heel contact dynamics (slower heel velocity) were observed when carrying a load. Finally, all of these changes along with postural modifications led to decreases in the joint moments, particularly at the hip. For most of these variables, there were no significant differences between the 2.3 and 6.8 kg load conditions. These results suggest that people adapt their gait when carrying loads to reduce slip and fall potentials.

Acknowledgments: NIOSH grant 5 R03 OH03621-02.

F1.4 Method of Expressing Slipperiness in Gait—
Noguchi T

To prevent the slips accident which happens frequently in winter, the method of expressing slipperiness in gait is introduced.

First of all, the three component of ground reaction force in gait is measured by force plate. Next, a ratio of horizontal component to perpendicular component of ground reaction force is calculated. The ratio is called Magnitude of Tangential Force Ratio (S). The tangent of fore and after component and right and left component of ground reaction force indicates the Direction of Tangential Force.

The center of pressure is assumed to be origin, and Magnitude of Tangential Force Ratio and Direction of Tangential Force are represented in polar coordinate system. The locus in the vector is drawn according to the passage of gait time. This figure is called Vector Locus. A circle of the same radius as the coefficient of friction (m) of the road is drawn in this Vector Locus repeatedly.

The pedestrian begins to slip when the Vector Locus is corresponding to this circumference. Additionally, slips are assumed for the period from which the Vector Locus has come out to the outside of the circle. Therefore, slipperiness and the direction of slips can be intuitively distinguished by this figure. Moreover, the value defined in the ratio of time that Vector Locus comes out outside of this circle [T(S>m)] and the time between stance phases (Tall) is called Danger Coefficient of Slip (DCS). DCS can be shown by the following expression.

$$DCS = T(S>m) / Tall (1)$$

By expressing slipperiness by using these Vector Locus and DCS, an objective diagnosis and guidance concerning slips in gait become possible. For example, when the coefficient of friction of the road is assumed to be 0.1, DCS has been improved from 60% to 20% by slowly walking on the right foot.

Session: F2.0

Title: Workplace Violence Research: Past, Present and Future

Category: Special Session

Organized by Lynn Jenkins, National Institute for Occupational Safety and Health

Moderator(s): Lynn Jenkins

F2.1 History and Status of NIOSH Research on Workplace Violence—Jenkins EL

NIOSH has been conducting research on workplace violence since 1988. A number of studies have been published, focusing first on workplace homicide and then expanding to include nonfatal workplace assault. NIOSH has focused on improving surveillance data, integrating information from multiple sources, and identifying risk factors and prevention strategies. A hallmark of these activities has been outreach and collaboration—bringing together government and academic researchers in both public health and criminal justice, along with labor, industry, human resources, legal, and employee assistance professionals.

Violence is indeed a substantial contributor to death and injury on the job. Homicide has become the second leading cause of occupational injury death overall and is the leading cause of occupational injury death for women. Estimates of nonfatal workplace assault vary depending on the data source, but data from the National Crime Victimization Survey indicate that each year from 1992-1996, more than 2 million workers were victims of a violent crime while working or on duty.

Risk factors for workplace violence include dealing with the public, the exchange of money, and the delivery of services or goods. Prevention strategies for minimizing the risk of workplace violence include (but are not limited to) cash-handling policies, physical separation of workers from customers/clients, good lighting, security devices, escort services, and employee training. A workplace violence prevention program should include a system for documenting incidents, procedures to be taken in the event of incidents, and open communication between employers and workers. Because no single prevention strategy is appropriate for all workplaces, workplace violence prevention efforts should be tailored to the risks in particular workplaces. NIOSH, along with others in the occupational safety and health community, is beginning to evaluate the effectiveness of various strategies in high-risk settings, so that intervention efforts can be most effectively targeted.

F2.2 Evaluation of Risk Factors for Robbery and Employee Injury and Compliance to a Workplace Violence Intervention in High-Risk Business Settings—Casteel C, Peek-Asa C

Introduction: Homicide is the second leading cause of U.S. workplace death. The majority of these deaths are robbery-related, and although many businesses are at risk, risk factors have been described only for convenience stores. Robbery and violence prevention programs have been implemented in convenience stores and have generally been effective. The extent to which these programs are effective in other business settings depends on similarities in risk profile and program compliance.

Objectives: Identify risk factors for robbery and employee injury in retail and service businesses, and describe compliance to a workplace violence intervention introduced into these businesses.

Methods: Liquor, grocery and convenience stores, restaurants, and motels in Los Angeles were eligible, and 400 businesses enrolled. Baseline assessments were conducted to identify risk factors for robbery and violent injury. Businesses received a workplace violence prevention program composed of low-cost measures found to decrease violence in convenience stores. Follow-up interviews were conducted to document changes due to the program.

Results: Many risk factors for violence analogous to those in convenience stores were found. At baseline, 89% maintained large cash amounts in the registers, 56% had obstructed visibility into the business, and 75% had insufficient interior lighting. Although robbery training was offered in 58% of the businesses, most of these programs were found to be inadequate. Two-thirds of the businesses had video cameras and 72% had burglary alarms. Comprehensive security programs were almost non-existent. Following program implementation, 66% of the businesses introduced training programs, 65% introduced cash handling procedures, 57% increased lighting, and 41% cleared window obstructions.

Conclusions: Most businesses lacked adequate prevention measures to reduce robbery-related violence. However, many had equipment systems, which focus less on robbery and violence prevention and more on suspect apprehension and merchandise protection. Compliance levels indicate that implementation of low-cost program components is feasible in small businesses.

F2.3 Evaluation of OSHA Guidelines on Preventing Violence in Mental Health Settings—Lipscomb JA, Rosen J

Workplace violence is pervasive in the mental health care setting. In 1996, Federal OSHA published violence prevention guidelines for health and community workers. These performance-based guidelines, although based on sound principles of safety and health, have never been formally evaluated in the field. Following the publication of the Guidelines, a joint labor/management initiative was launched within New York State Office of Mental Health (OMH) to implement the OSHA guidelines. The University of Maryland and New York State labor and management seized the opportunity of this initiative to evaluate the effectiveness of the OSHA guidelines in four NYSOMH facilities: two adult psychiatric, one child psychiatric and one forensic facility. The team of researchers and facility-based project advisory teams are using participatory research methods to implement and evaluate the effectiveness of the intervention. Each facility's intervention includes the key elements of the OSHA guidelines. Management Commitment and Employee Involvement are inherent in the design of the study and include the formation and work of joint labor-management advisory groups. A Hazard Analysis includes review of existing data, focus groups, a pre-intervention survey, risk mapping and walk-through evaluation. Hazard Prevention and Control will be accomplished by implementing recommendations from the hazard analysis. The advisory groups in consultation with project staff will review and make recommendations for policies and procedures on Medical Management and Post-incident Reporting and Training and Education. Training on a comprehensive violence prevention program will be offered annually. Formative evaluation of the project will be on-going. Evaluation of the Program, will be accomplished through analysis of a post-intervention survey and existing data one year following the implementation of the intervention. An in-depth analysis of the cost and benefit of the intervention will be conducted. Work to date in forming the various facility-level advisory groups and implementing the intervention will be presented.

F2.4 Workplace Violence Intervention Research: An Agenda for Action—Merchant J, Lundell J, Zwerling C

A workshop was held on April 5-7, 2000 in Washington, DC with the primary goal of developing a workplace violence prevention and intervention research agenda. Approximately forty invited representatives from federal and state agencies, employers, unions, the insurance industry, law enforcement and security groups, professional societies, and universities participated. Selected workshop participants developed white papers on the topics of (1) surveillance and epidemiologic data; (2) laws, regulations, and enforcement efforts; (3) industry-based programs; and (4) community and union-based programs. These served as the starting point for

workshop discussions. As well, the typology of workplace violence that distinguishes between four distinct types of events helped to organize workshop discussions. The four categories of workplace violence are: Type I-The perpetrator has no legitimate relationship with the workplace and is committing a criminal act prior to the violence (e.g., robbery, shoplifting); Type II-The perpetrator has a legitimate relationship to the workplace and becomes violent during a transaction or delivery of goods/services (e.g., customers, clients, students, patients); Type III-The perpetrator is an employee or past employee and threatens or attacks another employee(s) or past employee(s); and Type IV-The perpetrator does not have any relationship to the workplace but has a personal relationship with the intended victim. Both large and small group discussions were employed and served to facilitate brainstorming as well as refinement of ideas. Several overarching themes emerged such as the need for improved surveillance in order to better inform intervention efforts, the need for participatory research approaches that involve all interested parties in the development, implementation and evaluation of interventions, the need for different approaches for the four different categories of workplace violence, and the critical need for evaluation research of all kinds (process, impact and outcome).

Session: F4.0

Title: Needlestick/Eye Injuries

Category: Injury Surveillance

Moderator(s): Thomas K. Hodous

F4.1 Injuries and Illnesses in Nurses in Delhi—Joshi TK, Jugal Kishore, Sagar B, Singh B

Introduction: Occupational hazards in health care workers including nurses are well recognized, more so in developing countries due to inadequacy of health and safety programs.

Objectives: To study the frequency of injuries and illnesses in nursing care workers in a teaching hospital in Delhi.

Sample: A sample of 123 nurses out of 400 working in different health care facilities under Delhi Government.

Tools: Each subject filled up a Pre-tested Self Reporting Questionnaire after giving an informed oral consent.

Variables: Number of injuries occurring in last one week, abuse and violence at workplace, illness status, vaccination, use of PPE, and general socio-demographic data was collected.

Analysis: Data was analysed using WHO software package Epi-Info. Appropriate statistical tests were applied.

Result: There were 4016.2 needle prick injuries per 100 nurses years. Most injuries occurred in operation theatre and medical

ward. Nearly 10% reported workplace abuse and violence. Low back pain was reported in 33.3%, sprain in 6% and burns in 1.6% of nurses. The range of illnesses reported was varied and a total of 36.6% were on medication. The contact with blood infected with HIV was 17.4%, and with Hepatitis B 27.0%. Such contact was more frequent in operation theatre, burn and medical wards. Majority (80%) reported the availability of gloves. However, only 47.8% reported using them always. 54.5% were vaccinated against hepatitis B. 22% reported glove allergy presenting as itchy skin (84%). Use of tobacco products and alcohol was not reported.

Conclusion: Injuries and illnesses were frequent in nursing care workers. Immunization and use of protective equipment was not universal despite availability. There is an urgent need for health surveillance and well-designed training program to prevent injuries and illnesses in Delhi.

F4.2 Sharps-Related Injuries in California Healthcare Facilities: Preliminary Results From the Sharps Injury Registry—Gillen M, Davis M, Lewis J, McNary J, Boyd A, Curran C, Cone J

Background: Senate Bill 2005 (Thompson) mandated that the California Department of Health Services (CDHS) collect information on sharps-related injuries from healthcare facilities, on a voluntary basis. Under contract with the University of California, San Francisco, a Sharps Injury Registry was created. The aims of the registry are 1) to collect statewide data on sharps injuries; 2) to disseminate this information in aggregate form; and 3) to assist healthcare workers and facilities in making informed decisions to better protect care providers from sharps injuries and life-threatening illnesses.

Methods: A letter inviting participation in the registry was sent to California hospitals, home health agencies, and skilled nursing facilities (n = 2,654) along with a sample sharps injury log. Data was accepted in all formats, including hand-written, electronic, and summary reports.

Analysis: As of 12/31/99, reports of approximately 2,000 sharps injuries from 213 facilities have been received. Data has been collected on the following variables: type of facility, date/time of injury, sex, age, job classification, department, procedure being performed by the original user of the sharp (e.g., injection), procedure being performed by a non-original user of the sharp, when indicated (e.g., cleaning room), circumstances surrounding the injury, body part, type of device, activation of safety mechanism, when appropriate, and the employee's opinion regarding safety equipment use and work practice controls. (Note: Data is currently being reviewed by the CDHS and will be released in the near future.)

Conclusions: Despite the voluntary nature of this project, these findings represent an attempt to collect sharps injury

data on a statewide basis. Accepting non-standardized data makes interpretation of the results more complex. However, they may enable employers to make informed choices on work practices they foster and the devices they use to minimize the risk of sharp-related injuries to health care workers.

F4.3 Characterization of Needlestick Injuries and Development of Prevention Strategies—Frederick LJ, Williams JM

It is estimated that 590,000 needlestick injuries (NSI) occur among healthcare workers each year. Although the standard has been in effect since 1992, NSI continue to be a major problem among healthcare workers. In spite of education programs and the greater availability of engineering controls, recapping of needles continues and safer needles and needleless systems, when instituted, are not always accepted. Needles continue to be left in inappropriate places or improperly disposed of in regular trash where downstream workers can get injured. Requirements of the Bloodborne Pathogens Standard include reporting of NSI, however, many go unreported and fewer than 10% are recorded on the OSHA 200 log.

This study examined the characteristics surrounding NSI among a group of healthcare workers in a 380-bed tertiary hospital over a two-year period. A list of injured employees was generated from an Emergency Department database using International Classification of Disease (ICD) codes. The following information about each injury was obtained from medical records: work activity at time of injury, where injury occurred in the institution, type of device used and job classification. A literature review was conducted to identify available NSI controls. Eighty-six incidents were identified and descriptively analyzed. The most common work activities (65%) were procedural (e.g., starting or discontinuing intravenous therapy equipment) followed by disposal-related activities (22%). The most common procedure involved manipulation of IV therapy equipment; five percent involved recapping. By analyzing the injury data from this study and the information from the literature review, risk factors and prevention strategies for NSI were identified and categorized using an injury analysis model known as Haddon's Matrix. The findings of this study can be useful in developing prevention programs aimed at reducing the risk of NSI in healthcare facilities.

F4.4 Does Occupational Exposure Account for Excess Injury Risk: Serious Eye Injuries in the U.S. Army—Smith GS, Lincoln AE, Wong TY, Amoroso PJ, Vinger PF, Bell NS

Purpose: To determine if occupational exposure explains demographic variations (age, sex and race) in ocular trauma among U.S. Army soldiers.

Methods: The study population consisted of all U.S. Army personnel on active duty between 1980-1997. Hospitalization and personnel data were provided by the Total Army Injury and Health Outcomes Database. Serious occupational eye injuries were defined as any injury or foreign body affecting the eye or adnexa requiring hospitalization that occurred while on duty. Rates of ocular trauma were calculated for both broad occupational groups and selected specific jobs. Multivariate logistic regression models were used to evaluate the independent effect of broad and specific occupation on the risk of ocular trauma.

Results: The overall rate for on-duty hospitalized eye injuries for all persons in the military was 27.5 per 100,000 person-years (PY), though it varied widely by occupation. Men had 3.2 times the risk of women (95% CI: 2.7, 3.8), which was reduced to 2.3 after adjusting for broad occupational group, and 2.0 after adjusting for specific job. Whites experienced significantly higher rates than blacks (Incident rate ratio (IRR) = 1.3, 95% CI: 1.2, 1.4) and the excess changed little after adjustment for occupational exposure. Crude age-specific rates consistently rose from the oldest group (41+ years) to the youngest group (17-20 years old) (IRR=6.7, 95% CI: 5.0, 9.2). For some specific jobs, age was directly related to increased risk but demonstrated an inverse risk for others, suggesting an age-job interaction.

Conclusion: Most studies have found that demographic differences in injury rates are much reduced when occupational exposure is accounted for. However, using occupation to control for exposure, we found that young, white men in the U.S. Army maintained the highest risk of work-related ocular trauma, even when performing work activities very similar to those of other demographic strata.

Session: F5.0

Title: Methods and Results

Category: Safety Communications and Training

Moderator(s): Paul A. Schulte

F5.1 Using the Extended Parallel Process Model to Develop and Evaluate Silicosis Prevention Materials for Masonry Workers and Contractors—Day BT, Tan-Wilhelm D

Overexposure to crystalline silica is well documented in the construction industry, especially in brick laying and masonry. According to a recent study, approximately 17,400 masonry and plastering workers may be exposed to at least five times the NIOSH recommended exposure limit (REL) for crystalline silica and of these workers, an estimated 80 percent may be exposed to at least 10 times the NIOSH REL.

A study was designed for the purpose of educating both non-union and union contractors and workers about the hazards of silica dust. The study involved collaborations

with the International Union of Bricklayers and Allied Craft Workers, North Carolina Masonry Contractors Association, and the Amerisure Insurance Company. A two part study was implemented: first, a series of six focus groups were conducted with both masonry workers and contractors to assess worker and contractor concerns related to dust in the workplace and their threat and efficacy perceptions regarding silica dust and respiratory protection methods. Second, the results of the focus group discussions were analyzed and then incorporated into educational materials that were implemented and evaluated in a 2x2 factorial, pre-post test experimental design. The educational materials were developed using a framework based on the Extended Parallel Process Model. Pre and post questionnaires assessed threat, efficacy, behavior, and safety climate to evaluate changes related to the educational materials. It is expected that the educational materials will increase perceptions of threat and efficacy among contractors and workers; and particularly among the non-union participants. Work site observations will be conducted at both control and experimental group locations to determine if work site behavior was affected by the program.

F5.2 Expert Systems for Communication in Occupational Safety and Health—Botkin A

OS&H managers must communicate rules and regulations to a wide variety of audiences with different levels of understanding and needs. Limitations of staff availability generally preclude a personal tailored answer for each question and concern. One application that solves this problem is the expert system.

An expert system is based on a series of if...then statements. These statements represent the parameters of a human expert's knowledge or the agency's regulation. The user of an expert system is asked a series of questions derived from the if...then statements. Based on the responses to the questions, the computer program then responds with the information or guidance that is needed by the user. The expert system allows repeatable and verifiable instructions to be communicated to users based on the knowledge of subject matter experts.

OSHA has developed a series of these expert systems to assist its regulated community in complying with the directives of the agency. One example of this is the Hazard Awareness Expert Advisor, which assists small businesses in understanding the OSHA regulatory system by identifying those regulations that are applicable to their situation. It asks questions about the industrial or commercial processes, operations, and other characteristics of the facility where the business is located. It then identifies those regulatory passages which the owner should further investigate.

Not every regulatory issue benefits from the development of a system, but many problems that are characterized as routine

by an expert prove daunting to those seeking to comply with regulations. By providing expert systems guidance, the agency can free the time of human experts for more complex problems, and provide the regulated community an easy avenue of information.

F5.3 Key Learnings From Electrical Safety Workshops Sponsored by IEEE 1992-2000—Floyd HL, Eastwood K, Bonner S, Jamil S, Liggett DP, Pace DA, Satish C

Following the issuance of OSHA 1910 subpart S in 1990, the Institute of Electrical and Electronics Engineers, Inc. (IEEE) organized an annual 3 day workshop for preventing workplace injuries from electrical hazards. The first workshop was held in 1992 with 37 participants. By 2000, it grew to 150 people from more than 70 industrial companies and organizations. The theme, "Changing the Electrical Safety Culture", targets assumptions, values, and beliefs that define current culture and that may be limiting breakthrough improvements in product designs, work practices, and managing systems. Attendees have these areas of interest: facilities design, construction, plant operation and maintenance, improved safety products and, training and safety services, government agencies, forensic engineering, standards development, legal and medical professionals.

The workshops focused on the practical application of codes, standards, technology, and implementation methods that reduce the risk of electrical injury in the workplace. The topics included: content of government regulations, update on evolving codes and standards, design practices for reduced risk, practices for assuring equipment integrity, personal protective equipment, arc flash hazard analysis, employee training, audit techniques, medical research of electrical injuries, safety program design and implementation, accident case histories.

The workshops have served as forums to advance technology, establish best work practices and accelerate improvement in standards and regulations to reduce electrical incidents, prevent injuries, and reduce the economic impact of mishaps in critical electrical energy and control systems. They have accelerated the normal evolution in the "culture" of electrical safety, and have proven to be unique offerings to facilitate and accelerate advancements in both the development and application of codes, standards, regulations, product design and work practices. The small, initial network has expanded to include participants from many corporations and professional organizations, and has linked professionals and centers of excellence in industry, engineering, government, and medicine.

F5.4 Agricultural Commodity Based Safety Programming: Using Florida Citrus as a Model—Lehtola CJ, Brown CM, Andrews LE

Traditional approaches for agricultural worker safety were developed for areas of the United States where growing seasons are well defined, the number of major commodities is small, and the scope of agricultural tasks is relatively limited. Therefore, safety messages and programs for these workers can be fairly uniform and timed to coincide neatly with the annual cycles of planting and harvesting.

By contrast, Florida produces over 40 major commodities, which produce over \$1 million per year each. However, variety of crops is only one aspect of Florida's traditional agricultural diversity. The commodities differ as to annual schedule, required equipment, job tasks, and workers. The hired labor force is comprised of both migrants and permanent residents with varied educational and literacy levels and from many national and linguistic backgrounds. Operations, as well, vary across the state. In the panhandle, small, privately owned farms depend on the family for labor. In central and south Florida, typical farms are large and commercially owned and operated.

Florida farm workers require safety programs developed around the needs of specific commodities. Early research in this area has focused on Florida's citrus industry.

A commodity-targeted approach to safety can be developed by profiling a specific commodity in terms of: component tasks, steps required for each task, time of year, required equipment/tools, the workers (literacy, language, or culture considerations), known problems, and major changes expected in the next 5-10 years.

This paper presents a methodology for developing commodity-targeted safety programs. Research results from efforts in the citrus industry are used as an example of how to use the programs in commodity-specific management decision-making models.

F5.5 Evaluating the Effectiveness of a Tailored Website for Construction Safety and Health—Donlin M, Linn H, Olevitch L, Tan-Wilhelm D, Day B, Lukwago S, Kreuter M, Rowel R

A tailored health or safety message is one that is customized for an individual user based on that user's responses to a set of assessment questions. Assessment questions ascertain characteristics of the user including but not limited to behaviors, intentions, attitudes, knowledge, work experience and practices, health beliefs, and self-efficacy. Specific responses to assessment questions or combinations of specific responses lead to the retrieval of customized messages that are dynamically combined in a print or electronic

document and returned to the user. Computer tailoring has been evaluated for several important health topics among at-risk populations, including diet, injury prevention, smoking cessation and mammography. This study is the first application of computer tailoring for occupational safety and health topics among industry-based populations, such as the residential building contractors studied here.

This research compares the effectiveness of four intervention programs to increase knowledge, positive safety and health program practices, and perceptions of self-efficacy of construction contractors related to the risk of falls from elevations and exposure to crystalline silica dust among their workers. The interventions include: a tailored Website, a nontailored Website, tailored printed material delivered by direct mail, and nontailored printed material delivered by direct mail. A study population of 250 homebuilders has been recruited. Implementation will commence in June/July 2000, and findings will be available for presentation at NOIRS 2000 in October.

Session: F6.0

Title: Injuries in the Construction Industry II

Category: Special Populations: Construction

Moderator(s): David E. Fosbroke

F6.1 Contractor Safety Practices and Injury Rates During Construction of Denver International Airport—Glazner JE, Borgerding J, Bondy J, Lowery JT, Lezotte DC, Kreiss K

Background: We sought to explain variation in injury rates found for categories of companies and contracts involved in the construction of Denver International Airport (DIA) by surveying contractors about company and contract-level safety practices.

Methods: We conducted 213 telephone interviews (83% response) with representatives of contracts with payrolls of more than \$250,000. We investigated the relationship between safety actions reported in the survey and injury occurrence by calculating aggregate injury rates (lost-work-time (LWT) rates and non-LWT rates) for the group of respondent contracts reporting always taking the action and for the group not always taking the action. Using Poisson regression, we examined the association between contract injury rates and contract safety practices, controlling for variables previously shown to affect contract-level injury rates.

Results: In Poisson regression, two actions, (1) disciplinary action always resulting when safety rules were violated and (2) contractors always considering experience modification ratings when selecting subcontractors, were associated with lower LWT injury rates. Three actions or contract characteristics resulted in lower non-LWT rates: management always establishing safety goals for supervisors, conducting drug testing at times other than badging or after an accident,

and completing the DIA contract on budget, rather than over budget. In contrast, reportedly consistent use of a number of accepted safety practices was associated with significantly higher injury rates in bivariate and multivariate analyses.

Conclusions: The pattern of counterintuitive results found in this study suggests that survey questions reflecting agreed-upon safety practices, when asked of the person responsible for all on-site construction activities, are likely to elicit normative responses. Objective validation of reported safety practices, when used in conjunction with measures of both time at risk and outcome as well as control for prevailing risk of the work performed, is critical to evaluating their efficacy in reducing injury rates.

F6.2 Analysis of Construction Injury Burden by Type of Work—Lowery JT, Glazner JE, Borgerding JA, Bondy J, Lezotte DC, Kreiss K

Background: To lay groundwork for identifying patterns of injury etiology, we sought to describe injury experience associated with types of work performed at construction sites by examining workers' compensation (WC) claims for the 32,081 construction workers who built Denver International Airport (DIA).

Methods: Injury rates and WC payment rates were calculated for 25 types of work based on claims and payroll data reported to DIA's owner-controlled insurance program according to National Council on Compensation Insurance job classifications. By linking DIA claims with corresponding lost-work-time (LWT) claims filed with Colorado's Workers' Compensation Division, we were also able to obtain total and median lost days for each type of work.

Results: Injury experience varied widely among types of construction work. Workers building elevators and conduits and installing glass, metal, or steel were at particularly high risk of both LWT and non-LWT injury. Median days lost by injured workers was the highest (202 days) for driving/trucking. Median days lost for most types of work was much greater than previously reported for construction: 40 days or more for 18 of the 25 types of work analyzed. WC payment rates reflect both number and severity of injuries and were generally not significantly different from expected losses. They were, however, significantly higher than expected for driving/trucking, metal/steel installation, inspection/analysis, and elevator construction.

Conclusion: Analysis of injury data by type of work allows targeting of safety resources to high risk construction work and would be useful in prospective surveillance at large construction sites with centrally administered workers' compensation plans.

F6.3 Work-related Falls in Residential and Drywall Carpentry—Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D

Workers' compensation records provide limited information about injury circumstances, etiology and potential interventions. To overcome these obstacles an active injury reporting/investigation program, modeled after NIOSH's Fatal Accidents Circumstances and Epidemiology program, was established with the Carpenters' District Council of St. Louis for residential and drywall carpenters. Twenty-five contractors (3 million hours of union work/year) report recordable injuries as they occur. Journeymen carpenters interview injured workers using a standard format. Sites where falls occur are visited to assess fall hazards and factors reflecting overall safety climate. Worker and investigator report factors that could have prevented injury. The evaluation of falls in the first reporting year* are described.

Twenty-five falls (68% from elevations) have been investigated accounting for 14% of injuries. Half of falls from the same level resulted in lost time compared to 66% of falls from elevations - which were also more serious. The vast majority of falls occurred on single-family sites at the stage of first level framing. Over half of victims had over 5 years experience with their task when they fell and only 13% had less than a year of experience. 83% who fell from the same level were aware of a site fall protection plan compared to 55% who fell from elevations.

Same level falls were related to site conditions — grade of lot, wet/frost, housekeeping. Workers felt these could have been prevented by more attention to task and less emphasis on speed. Falls from elevations occurred because of uncovered openings, lack of rails or personal protective equipment, ladder/scaffold failures, actions of co-workers. Findings document training needs for scaffold assembly, movement and work practices, equipment maintenance, coordination of tasks. Workers commonly attribute falls to their own behavior but more often for falls from the same level.

* These data (first 7 months) will be updated before presentation

F6.4 Nail Gun Injuries in Construction: Need for Gun Control?—Dement JM, Lipscomb HJ, Li L, Nolan J, Patterson D

The nail gun is a potentially dangerous device commonly used in construction. Data were combined from 3 sources to collect information about injuries resulting from nail guns among construction workers. Workers' compensation records were obtained for non-union homebuilders (7500 contractors; 9,205 injuries) in North Carolina 1995-1999 and union carpenters (13,487 carpenters; 4,138 injuries) in the state of Ohio 1994-1997. Relevant injuries were identified from text

data from first reports of injury. These records-based data were supplemented with information collected in the first year of an active injury reporting and investigation program among unionized residential and drywall carpenters in Missouri representing 3 million work hours per year. The latter provided more detailed descriptions of the circumstances of injury and potential points of intervention.

We reviewed 450 injuries resulting from nail guns. Among residential carpenters/homebuilders, nail gun injuries account for the largest proportion of injuries resulting from being struck (20-35%). The vast majority of injuries involved the extremities and eyes. However one individual was shot in the chest, one was shot in the head and three sustained head injuries from falling guns. A number of victims were not actually operating the guns themselves when injured. Their injuries resulted from complete penetration of the receiving structure and accidentally discharging guns.

Ricocheting nails or wood, accidental discharge, penetration of structures, falling objects, unsafe location or operation of guns and falls all contributed to these injuries. Safety mechanisms for these devices were often bypassed. Findings indicate that combined engineering design improvements, personal protective equipment such as appropriate eye protection, housekeeping improvements to prevent falls, and effective operator training could decrease these common and potentially devastating injuries.

F6.5 Eye Injuries at a Large Construction Project: A Better Understanding Through Compensation Data and Injury Investigations—Jackson LL, Borgerding JA, Lowery JT, Glazner JE

The construction of Denver International Airport (DIA) in 1989 through 1994 represented more than 31 million hours of work completed by over 32,000 workers. In December 1990, an owner-controlled insurance program (OCIP) began providing workers' compensation insurance for all contractors and included an on-site medical clinic and designated provider/medical referral system.

We analyzed the OCIP injury database of 4,634 claims with medical payments along with injury reports (for ~90% of claims) and accident investigation reports (for ~50% of claims) from the building of DIA to develop a better understanding of construction-related eye injury risk factors.

An estimated 14% (649 claims) of compensation claims with medical treatment (other than simple first aid) were eye injuries. Eye injuries occurred mostly to men (96%) who were frequently younger than 40 (66%). A foreign body in the eye was most frequently reported (87%) with some burn (8%), contusion (2%), and laceration (1.5%) eye injuries. The majority of eye injuries occurred disproportionately to special trade contractors—SIC 17 (68%). Heavy construction

contractors, SIC 16, and building construction, SIC 15, had far fewer eye injuries (15% and 10%, respectively). Among the construction trades, electricians had the most eye injuries (30%), followed by cement masons (19%), operating engineers (13%), plumbers (10%), and iron workers (9%).

Injury investigation reports provided additional details on the injury event and for about one half of the injuries indicated if safety eye protection was worn at the time of injury. Among these cases with additional information, most workers reported wearing some form of safety eye protection at the time of injury and that objects commonly went around the protection—particularly when working overhead.

The OCIP injury data in combination with the investigation reports provide a unique perspective on construction eye injuries.

Session: G1.0

Title: The NIOSH Fatality Assessment and Control Evaluation Project's Role in the Reduction of Occupational Fatalities

Category: Special Session

Organized by Virgil Casini, NIOSH FACE Team

Moderator(s): Paul Moore

G1.1 Overview of the National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) Program—Higgins DN

The NIOSH Fatality Assessment and Control Evaluation (FACE) program is a research program designed to identify and study fatal occupational injuries. The goal of this program is to prevent occupational fatalities across the nation by identifying and investigating work situations at high risk for fatal injury and then formulating and disseminating prevention strategies to those who can intervene in the workplace.

The FACE project currently has two major components. The first component is the in-house program which began in 1982. Five states (NC, SC, TN, PA, VA) voluntarily notify NIOSH of traumatic occupational fatalities occurring in the targeted areas that have included confined spaces, electrocutions, machine-related, falls from elevations and logging. In-house FACE is currently targeting investigations associated with machinery, deaths of youths under 18 years of age, and street/highway construction work zone fatalities.

The second component is the State-based FACE program which began in 1990. Currently, 15 State health or labor departments have cooperative agreements with NIOSH for conducting surveillance, targeted investigations, and prevention activities at the State level using the FACE model. These states include, AK, CA, IA, KY, MA, MO, MN, NE, NJ, OH, OK, TX, WA, WV, WI.

Surveillance data and investigative reports are maintained by NIOSH in a database. NIOSH researchers use this information to identify new hazards and case clusters. FACE information may suggest the need for new or revised regulations to protect workers. NIOSH publications are developed to highlight these high risk work situations and to provide safety recommendations. These publications are disseminated to target audiences and are available on the Internet through the NIOSH homepage or through the NIOSH publications office.

G1.2 New Jersey FACE Investigation Leads to Legislative Changes—Bost P

This presentation will explain the course of events that led to legislative changes following the electrocution of a lifeguard at a public swimming pool. On June 14, 1994, a twenty-year-old college student was working as a lifeguard at an apartment complex swimming pool. When he went into the pump room to adjust the chlorine flow, he died after contacted a pump motor that had been energized with 220 volts due to faulty wiring.

The NJ Department of Health & Senior Services, Fatality Assessment & Control Evaluation (FACE) Program was notified and conducted an investigation two weeks after the incident. Investigators found that the 20 year-old pump equipment had not been inspected or maintained for at least ten years and made recommendations to improve swimming pool electrical safety. Recognizing that this problem may exist at other public swimming pools, NJ FACE published a warning bulletin highlighting the incident and our recommendations. This bulletin was distributed to NJ public swimming pools by the local health departments during their sanitary inspections.

As a result of the FACE investigation and warning bulletin, a municipality changed their codes to require periodic inspections of swimming pools. In February 1996 two members of the NJ State Assembly introduced a bill to modify the state construction code establishing basic electrical standards for swimming pools. The bill was passed on February 10, 1999 requiring that all public swimming pools, hot tubs, and spas obtain an electrical certificate of approval. A licensed electrical contractor or testing agency would issue this certificate following an inspection of the pools bonding, grounding, and general electrical systems. A facility would not be allowed to legally open without obtaining this certificate.

G1.3 Youth Farm Worker is Killed in PTO Driveline Entanglement—Johnson WE, Rautiainen RH

In January 1999, a 17-year-old high school student working part-time for a dairy farmer was killed when his clothing was caught by the unshielded power take-off (PTO) driveline of

an old grinder-mixer. He had been helping the farmer add sacks of feed supplement to ground corn in the mixer. The supplement hopper on this machine was not operational and the hammer mill opening was used instead. This opening was next to the unshielded driveline and a flywheel, which was disconnected and not rotating at the time. After having added the supplement, the farmer was closing the hammer mill cover. The youth was standing next to him, near the rotating unshielded PTO driveline. Suddenly the farmer heard a thump, then noticed that the boy had been caught and entangled around the driveline at the flywheel clutch. The idling tractor stalled from the force, and the youth died instantly from decapitation.

Iowa FACE investigators learned about the incident from a co-worker, who was alerted by a radio news report. Information was gathered from several sources including a site investigation. The NIOSH Division of Safety Research was also notified of this fatality by the United States Department of Labor, Wage and Hour Division, and this report was produced in collaboration with NIOSH FACE staff. The report was requested by an Iowa Senator to be used in a subcommittee on agricultural safety standards for youth farm workers.

G1.4 The NIOSH, OSHA, NATE Partnership for the Prevention of Injury to Telecommunication Tower Construction and Maintenance Workers—Casini VJ

The widespread use of wireless communications services has fueled the construction of towers to hold transmitting devices for cellular phones, personal communication services, and television and radio broadcast antennas. The Federal Communications Commission (FCC) estimates that at least 75,000 towers have been constructed in the United States, and industry groups indicate that 20,000 to 50,000 towers are erected each year. The Telecommunications Act of 1996 is expected to promote more tower construction to meet the increased demand for wireless communication services.

Based on an analysis of data from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries, a minimum of 95 workers died during the construction or maintenance of telecommunication towers during the 6-year period 1992-1997. Falls accounted for the majority of deaths of workers involved in telecommunication tower construction or maintenance. Eighteen percent of the deaths were associated with tower collapse. The remainder of deaths occurred when workers were struck by objects, such as parts of equipment or towers. NIOSH has investigated 8 tower-related fatal incidents. Two of the case studies will be presented.

In an attempt to improve the safety and health of tower workers, OSHA established a Tower Task Force in 1997. NIOSH has been an active member of this task force and has made several key contributions to the task force's products.

NIOSH and OSHA, together with the National Association of Tower Erectors, have addressed several key issues affecting the safety and health of tower workers.

NIOSH input has been instrumental in the development of OSHA compliance directives, has disseminated safety information through trade magazines, and has developed preventive recommendations for tower owners, tower construction companies, and tower workers.

G1.5 Dissemination of Products From the Fatality Assessment and Control Evaluation (FACE) Program—Morton LL

NIOSH develops publications to highlight high-risk work situations discovered through the FACE surveillance and investigation efforts. These publications provide safety recommendations and are disseminated to targeted audiences through the DSR Information Management and Dissemination Activity (IMDA). They are also available through the NIOSH homepage or through the NIOSH Publications Office.

When FACE Hazard Alerts or Hazard IDs are completed, IMDA and FACE personnel work together to identify the most appropriate audiences for the receipt of these documents. Where possible, NIOSH sends publications directly to at-risk companies. If the number of companies is too large, NIOSH must rely on “information gatekeepers” such as trade associations, labor unions, professional societies, etc., to further disseminate the information to their members/constituencies. Interpersonal phone contact with officials in these gatekeeper organizations often yields ideas and insights about other organizations and audiences to target. Once the audiences are identified, IMDA builds and maintains mailing lists which are used by the NIOSH Publications Office to distribute the Alerts and other information products.

For example, in 1995 IMDA was asked to identify the most appropriate audience for the Alert entitled Request for Assistance in Preventing Injuries and Deaths of Loggers. With input from the Alert authors and based upon the recommendations found in the Alert, IMDA identified the appropriate audiences for receiving the Alert. Some of these audiences included federal and state regulatory agencies, trade associations, logging companies, master loggers, safety and health training institutes, trade journals and newsletters.

IMDA recently developed a FACE homepage which is part of the NIOSH website. This site provides access to all investigative case reports completed by NIOSH staff, as well as investigative reports submitted by the 15 states working under cooperative agreements with NIOSH.

Session: G2.0

Title: Work-Related Burn and Amputation Surveillance: A Snapshot in Time of the Surveillance Results of Colorado, Kentucky, Utah and Minnesota

Category: Special Session

Organized by the Traumatic Injury SENSOR State grantees

Moderator(s): Wayne Ball

G2.1 Experience of Kentucky SENSOR Occupational Burn Surveillance—Scheerer A, Struttman T

Establishing the surveillance system for occupational burns in Kentucky began in October 1997. Before data collection could begin, it was necessary to put efforts into developing the questionnaire, refining methods, obtaining IRB approval and establishing a network to identify and report cases. Because there is no reporting requirement in Kentucky for occupational injuries, facilities needed to be recruited to voluntarily participate in the project. Recruitment of hospital burn units, emergency departments, outpatient clinics and a workers' compensation insurance company involved extensive communication through letters, phone calls and meetings. Several facilities declined to participate, mainly due to a history of treating few burn injuries or lack of staff availability. Currently, 25 facilities make up the reporting network. Follow-up phone interviews are conducted with the injured worker or the employer to obtain data about the work environment and how the burn occurred. Issues presenting challenges include facilities not reporting consistently or timely, and difficulty reaching the injured worker or employer by phone for an interview.

During 1998-1999, 314 cases were reported through the network. Ninety-three percent were treated on an outpatient basis, while 6% required hospitalization and 1% were fatal. The majority were thermal burns (64%), followed by chemical burns (16%), welding flash burns (9%) and electrical burns (6%). Restaurant workers made up a large portion of the cases with the industry category of eating and drinking places accounting for 28%; about 40% were due to hot grease.

G2.2 Work-Related Burn Surveillance Program in Utah—Marsden, RH

The purpose of this research project is to develop a complete registry of work-related burns in Utah, design and implement intervention activities, and ensure appropriate prevention activities are directed toward those industries identified as at risk.

Through surveillance activities, high risk industries, age groups, occupations, and environmental factors are being evaluated so that appropriate intervention strategies can be developed.

Burn cases are identified from hospital discharge data and outpatient clinics through ICD-9 codes. Medical records of burn cases are abstracted to identify work-related burn patients, and to obtain demographic, socioeconomic, and other risk factor information. Case and employer surveys are sent to obtain detailed risk factor information regarding the work-related burn incident. Educational materials are developed and distributed to high risk targeted industries and future site visits will be made to evaluate worker conditions.

Utah surveillance data indicates the incidence of work-related burns is significantly higher among males than females. Relative to age groups, persons 20 - 24 years of age demonstrated the highest incidence. Eating places accounted for most of the work-related burns by number. College graduates were less likely to be burned on the job than non-college graduates. The majority of work-related burns were from a thermal source. A wide majority of the respondents indicated that the work-related burn they received could have been prevented.

Analysis of data suggests that there is a great need for a focused work-related burn prevention program as most injuries were considered preventable, and most indicated they were injured performing a task which they perform daily. Two full years of data have been obtained, and continued surveillance of work-related burns is needed including the development of appropriate intervention strategies and measurement of the effectiveness of those strategies.

G2.3 Work-Related Burn Surveillance in Colorado: 1989 - 1997—McCammon JB

Funding Background: The Colorado Department of Health (CDH) conducted surveillance for persons requiring inpatient hospital care for occupational burns from 1989 through 1997 under funding from the National Institute for Occupational Safety and Health (NIOSH) Sentinel Event Notification System for Occupational Risk (SENSOR) program. The success of this program led to expanded surveillance through which data on both occupational and non-occupational hospitalized burn cases were collected. Funding for the non-occupational portion of the surveillance was part of a National Center for Injury Prevention and Control Injury Capacity Building interagency agreement that began in 1989 and ended in 1994, and through the University of Colorado Health Sciences Center Burn Rehabilitation Model Systems Program from 1995 through 1996.

Burn Surveillance Background: In May 1990, the Colorado Board of Health adopted regulations that required that all hospitalized burns and all burns resulting in death prior to hospitalization be reported to CDH within 30 days. Hospitals throughout the state were provided with a two-page report form to be forwarded to CDH (passive surveillance). Active

surveillance consisted of monthly telephone calls or visits to seven hospitals in the state. NIOSH and the two states conducting burn surveillance under SENSOR at the time (CDH and the Oregon Health Division) agreed upon a surveillance case definition for occupational hospitalized burns. Between February 1989 and June 1997, 548 occupational hospitalized burns were reported to CDH, of which 501 met the case definition.

Current Status: Injury data including burn data, are still available at CDH. In 1996, the Colorado legislature mandated the formation of a Trauma Registry as a result of pressure from physicians from the state's Trauma Institute. Limited State funds were allocated to be used to evaluate care of the trauma patient in Colorado. CDH continues to seek adequate stable funding for the Registry.

G2.4 Amputation Surveillance in Minnesota—Parker DL, Boyle D, Larson T

In the United States, between 16,000 and 21,000 people sustain work-related amputations each year (McCaffrey, 1981; Sorock et al., 1993; US Department of Labor, 1982). The rate of amputation varies from 1.5 to 3.7 per 10,000 full-time workers engaged within private industry or manufacturing. The highest incidence occurs among young males, those using machines, or working within manufacturing industry. The majority of amputations involve one or more fingers. Although a finger or fingertip amputation may not seem serious, finger dexterity is an integral factor for many jobs and loss of a fingertip may result in lost work time, loss of a job, or placement in an alternate position.

The Minnesota SENSOR has collected data on the nature, incidence, and cause of work-related amputation injuries since 1992. SENSOR defined an amputation as any finger amputation or loss of any other body part; 832 workers were identified as having amputation injuries between 1994 and 1995 and 72 percent of these workers completed telephone interviews. A majority of the individuals completing the telephone interview were male (86%), 14 to 44 years of age (75%), employed at least 30 hours per week (93%), and had no technical school or college education (54%). Ninety-three percent of these injuries were reported through the Department of Labor and Industry's first report of injury forms or through computerized disability rating records.

The amputation injury rate for Minnesota workers was 39 per 100,000 workers, with agriculture and manufacturing having the highest rates. Sixty-six percent of the injuries involved one finger; fourteen percent involved two or more fingers. Persons working with machinery reported 73 percent of the injuries. A closer examination of the incidence and causes for amputations shows that these were not random events. Reliance on human reactions to prevent injury is inadequate; therefore additional research needs to be conducted.

Session: G3.0

Title: From Virtual Reality to Reality

Category: Special Session

Organized by Hongwei Hsiao, National Institute for Occupational Safety and Health

Moderator(s): Hongwei Hsiao

G3.1 Virtual Reality for Safe Equipment Operation—Hollands R

AIMS Research at the University of Nottingham is involved in applying the latest computer technology to health and safety related training. Both computer animation and virtual reality (VR) technologies are used for different aspects of training. Computer animations can be used in video or multimedia training tools to demonstrate particular hazardous situations or even reconstruct real accidents. Virtual reality extends the graphic realism of computer animation to allow the trainee to explore and interact in real-time.

It is unfortunate that most people learn their most important lessons by making mistakes; however, in real-life learning, this often results in injury to personnel, damage to equipment, or disruption to production. By allowing these mistakes to be made within a virtual environment the risks are effectively removed, and managing the situations to which the trainee is exposed can result in the equivalent of many years on-the-job training, acquired in a very short time.

AIMS Research has developed a training application development tool called SAFE-VR which allows PC-based VR training applications for hazard spotting, equipment operation etc. to be easily created, without any programming knowledge required.

The benefits from using VR training technologies can be hard to assess numerically, although the literature abounds with anecdotal evidence showing reduced cost of training, reduced downtime of equipment and improved knowledge retention and skill levels. Unfortunately, traditional VR solutions were expensive to both create and maintain, resulting in unfavourable cost/benefit ratios. However, the advance of PC technology and 3D computer games now means that entry-level PCs could easily run simple VR training tools, and it should only be a matter of time before VR becomes as common a training tool as multimedia CD-ROMS are now.

G3.2 Employing Virtual Reality Simulations of Agricultural Tractor Operation for Assessing Safe Behavior Among Youth - A Feasibility Study—Stredney D, Sessanna D, Bryan J, Heaney C, Bean T, Wilkins JR

An integrated system that provides subjects with an immersive, real-time virtual environment for experiencing tractor rollovers has been developed. This system is based on relatively low-cost and portable equipment. The objective

of this work has been to assess the feasibility of employing Virtual Reality simulations of farm equipment operation as a method for evaluating the acquisition of safe behavior practices among 13- to 16-year-old youth who participate in the Ohio Tractor and Machinery Certification Program.

Through the integration of stereographic and audio stimuli with haptic (force reflection) interfaces, the prototype system presents a plausible real-time environment for experiencing tractor operation/interaction, including adverse outcomes like rollover. We have developed a functional, dynamic model of the tractor based on a discrete damped spring-mass system that approximates the physical behavior of a tractor and executes in real-time. A spring-mass mesh, or skeleton, has been created that represents a John Deere 8400 tractor. This skeleton is loaded into the simulator with the visual representational model and interacts with the environment to determine model behavior. We will present our current refinements to the system, its use in subject assessments, and discuss future developments and implementations.

G3.3 Safe Work at Elevation Through Virtual Reality Simulation—Dotson BW, Hsiao, H

Occupational safety research frequently involves measurement of human responses of workers under normal and extreme conditions, in their work environments, in order to provide recommendations to achieve safer work practices. Often, direct measurements of these responses in the field are not practical, due to safety concerns and the complexity and cost of developing nonintrusive evaluation procedures. Virtual reality simulations offer a solution to this problem.

NIOSH researchers are using virtual reality in studies which investigate the physical and mental responses of subjects while working at elevations. These studies will help us to provide recommendations on optimal work settings (e.g., minimum plank width when working on scaffolding at various elevations, visual references for reducing roofers' instability when working on complied or slope surfaces). The virtual reality system that NIOSH developed consists of three main pieces of equipment, an image generator, a surround-screen virtual reality(SSVR) system, and a position tracking system. The image generator produces the graphic images that are viewed on the SSVR. The images projected on the SSVR are stereoscopic, which means the left and right eye images are projected separately. The user wears a pair of LCD shutter glasses, which are synchronized with the projectors so that the user's eyes see the correct image. Viewing the graphical objects in stereo makes the objects appear to be three dimensional.

The VR technology is promising for other applications too. We are assessing the feasibility of 1) establishing a multi-directional treadmill for walk-at-elevation simulations, 2) designing portable motor vehicle simulation platforms for

work-zone safety simulations, 3) converting real world images into VR system, 4) developing additional walls for the current VR system to accommodate overhead work simulation (e.g., crane operation), and converting current SGI-driven system to PC-driven to reduce system maintenance cost.

G3.4 Driving Safety and Simulation Technology—Tabacchi JG, Grace R, Guzman AM

Motor vehicle crashes are one of the leading causes of work-related deaths and severe injuries in U.S. workers. The statistics show that many workers are at high risk of injury and death from traffic-related accidents. About three workers die from these crashes each day. It is important to realize that many of these accidents occurred due to human error. The potential of improving driving safety is huge particularly when new technologies such as driving simulators and on-board drivers monitoring systems are used for advanced driver training.

The Transportation Research Center of Carnegie Mellon Research Institute, (CMRI) is involved in research issues related to applications of driving simulators. Together with ISIM, a leader in the field of driving simulators, we have designed and developed an advanced driving research facility. A key component of the Center is its driving simulator named "TruckSim." This simulator allows researchers to safely test drivers under conditions that would be hazardous in the real world. During tests, drivers can be subjected to identical situations while their response and actions are recorded by a multitude of sensors mounted throughout the cab. This system has been used to study drowsiness and fatigue in sleep-deprived drivers and has helped us to develop a drowsy-driver-detection system. TruckSim's modular configuration allows for rapid and cost-effective design of human factors experiments. The system is capable of simulating a variety of road vehicles, using interchangeable cabs mounted on an electromechanical motion platform. TruckSim's driving environments and scenarios can be tailored to study the driver's response to hazardous conditions. Driving errors and crashes can be played back using an aerial view to give the driver another perspective of the road situation. The current and future uses of driving simulators are presented in this paper.

G3.5 Fire Dynamics Simulator—McGrattan K, Forney G, Madrzykowski D

Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The model solves numerically the conservation equations of mass, momentum and energy that govern low-speed, thermally-driven flows with an emphasis on smoke and heat transport from fires. A companion software package called Smokeview is an OpenGL graphics program that allows one to visualize the results of the calculations, including animations of smoke

particulate, temperature slices within the three-dimensional domain, and heat fluxes to walls. Users of the package can view the enclosure from any angle from inside or outside. Most users prefer to visualize the evolving fire scenario by way of two dimensional animated slices of temperature or gas concentration. Work is underway to introduce these types of quantities by means of three dimensional surfaces, depicting, for example, the layer of smoke near the ceiling of a burning room.

Future developments include the ability to immerse a target, like a fire fighter, within the space so that the temperature and thermal radiation flux to the body can be assessed. Present applications of the model include testing sprinkler performance in storage facilities and warehouse retail stores, reconstructions of fires in residential buildings, and simulations of large outdoor fires. The software is available to the public via the web site fire.nist.gov, and it has been designed to run either on high-end personal computers or engineering workstations.

Session: G4.0

Title: Selected Workplaces

Category: Injury Surveillance and Intervention Evaluation

Moderator(s): Anne-Marie Feyer

G4.1 Fatal Occupational Injuries in the U.S. Rail Transportation Industry—Fosbroke DE, Moore PH

The rail transportation industry is much safer today than in the days of link-and-pin couplers, brakemen jumping from roof to roof to set hand brakes, and train operations regulated by time tables and train orders. Although significantly improved since the 1890s, work-related fatal injury rates in this industry are currently more than twice the national average.

Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI) data were analyzed to assess the magnitude and distribution of fatal injuries in the rail transportation industry. Denominators for calculating fatality rates were estimated using the Current Population Survey. From 1992-1998, 226 rail transportation workers died of work-related fatal injuries in the United States. The fatal occupational injury rate was 11.2 per 100,000 workers per year. These statistics exclude worker fatalities in local and suburban transportation (e.g., commuter and light rail). Fatally injured workers were employed in 36 different occupations, but, 61% of the victims worked in train operation occupations, including railroad conductors and yardmasters (55 deaths), railroad brake, signal, and switch operators (45 deaths); and locomotive operating occupations (37 deaths). Seventy-five percent of cases involved either a railway event (48.2%), or a pedestrian struck by a vehicle or mobile equipment (12.8%). Eighty-one percent of incidents involved a rail vehicle (68.6%), or a motorized highway vehicle (12.8%). Circumstances associated with

fatal injury include being struck by, or caught between rail cars during switching and spotting of rail cars; operating locomotives, or riding on trains involved in derailments and collisions; riding in motor vehicles involved in highway collisions; and being struck by trains during repair, inspection, or maintenance activities. These results indicate that railway workers risk of injury is similar to that of workers in mining and construction where the need for improved safety measures has long been recognized.

G4.2 Transportation Incidents - the 500 Pound Gorilla of Occupational Injuries—Luchter S

Introduction: Occupational injuries are a major public health problem in the U. S., with over 6,000 fatalities and more than 1.8 million lost work day injuries a year. In order to focus prevention efforts it is important to know where the injuries are occurring and what type of events are causing them. This study was undertaken to determine the relative significance of transportation related injuries in the occupational setting.

Method: U. S. Bureau of Labor Statistics data on fatal and lost work day injuries in 1997 were analyzed to determine the distribution of these injuries by industry, event and outcome.

Results: Of all occupational fatal injuries reported for private industry in the U. S. in 1997, 40 percent were transportation related, with 83 percent of that total highway or motor vehicle related. These fatalities were the number one or number two cause of fatal occupational injuries in all industry categories and were not restricted to persons whose primary job was transportation. Transportation related non-fatal injuries resulting in lost work days comprised 4 percent of all lost work day occupational injuries. This is a small portion of the total, with overexertion, contact with object and falls comprising 28, 27 and 16 percent respectively.

Conclusions: Transportation related occupational injuries are a small portion of the injuries that result in lost work days, however, they are the number one or number two leading cause of occupational fatalities in all industry classifications. Although transportation related occupational injuries are relatively infrequent, when they do occur they are quite severe, resulting in a major portion of all occupational deaths.

G4.3 Impact of a Design Modification in Modern Firefighting Uniforms on Burn Prevention Outcomes in New York City Firefighters—Prezant DJ, Freeman K, Kelly KJ, Malley KS, Karwa ML, McLaughlin MT, Hirschhorn R, Brown A

Our aim was to determine the impact of 3 different firefighting uniforms (traditional, modern and modified modern) on incidence and severity of thermal burn injuries, the major occupational injury affecting firefighters. Injury data was

collected prospectively for the New York City Fire Department (FDNY) wearing FDNY's traditional uniform (protective over-coat) from 5/1/93-8/31/93, FDNY's modern uniform (protective over-coat and over-pant) from 5/1/95-8/31/95 and FDNY's modified modern uniform (short sleeve shirt and short pants rather than long sleeve shirt and long pants worn under firefighter's protective over-clothes) from 5/1/98-8/31/98. Outcome measures were burn incidence and severity. Adverse outcomes were heat exhaustion and cardiac events. During this 12 month study, 29,094 structural fires occurred; the incidence rate for upper extremity burns was 2,341 per 100,000 fires and for lower extremity burns was 2,076 per 100,000 fires. With the change from traditional to modern uniform distribution of burns per fire decreased significantly ($P=0.001$) for upper extremity burns (86%) and lower extremity burns (93%). Days lost to medical leave for upper or lower extremity burns decreased 89%. Burn incidence and severity were not significantly affected by the change to modified modern uniform. The distribution of heat exhaustion or cardiac events per fire was not significantly affected by the change from traditional to modern uniform and heat exhaustion was decreased ($P<0.001$) by the change to modified modern uniform. In conclusion, modern uniforms dramatically reduced burn incidence and severity, while the modified modern uniform significantly reduced heat exhaustion without significantly affecting thermal protection.

G4.4 The Impact of Protective Hoods and Their Water Content on Firefighter Burn Injuries: Laboratory Tests and Field Results—Prezant DJ, Barker RL, Stull JO, King SJ, Rotanz RA, Malley KS, Bender M, Guerth C, Kelly KJ

The New York City Fire Department (FDNY) is the largest fire department in the United States. In 1996, FDNY introduced the thermal protective hood as part of its modern fire protective uniform. The purpose of this study is to determine (1) the effectiveness of hoods in reducing head burns and (2) whether hood water content (dry, damp or saturated) affects the level of thermal protection. Laboratory (radiant heat performance, thermal protective performance, and fully dressed manikin) and FDNY field tests were utilized. Laboratory tests evaluated 4 different conditions (no hood, dry hood, damp hood, and saturated hood) exposed to 4 different heat fluxes (0.1, 0.25, 0.5 and 2.0 cal/cm²/sec) equivalent to approximate air temperatures of 200, 400, 600 and 2,250° F (3). Field tests compared FDNY head burns during 3 winters wearing the hood to 3 winters not wearing the hood. Compared to not wearing a hood, wearing a hood dramatically reduced head burns. This was true for all laboratory tests, at all heat flux exposures and all hood water content conditions. At 0.1 cal/cm²/sec, dry hoods were superior to wet hoods. At all other heat flux exposures, thermal protection was either not significantly different between water content conditions or improved as water content increased. FDNY field results confirmed these laboratory results. During the time periods studied, there were a total of 611 head burns

(64,444 structural fires of which 7,938 were classified as serious fires). Hood wearing produced significant decreases in neck burns (by 54%), ear burns (by 60%) and head burn totals (by 46%). Based on our combined laboratory and field results, we recommend the use of modern thermal protective hoods.

Session: G5.0

Title: Simulation Exercises

Category: Safety Communications and Training
Organized by Henry P. Cole, University of Kentucky
Moderator(s): Ted Scharf and Mike Colligan

G5.2 Simulation Exercises to Prevent Occupational Exposure to Blood and Other Body Fluids—Gershon RM, Karkashian, Christine D, Cole HP, Flanagan PA

Simulation Exercises to Prevent Occupational Exposure to Blood and Other Body Fluids An interventional study, designed to identify and develop innovative strategies to reduce health care workers' risk from bloodborne pathogens, was recently conducted. One of the strategies that was developed and evaluated was the use of simulation exercises to improve health care workers' adherence to recommended safe work practices. Participatory action research teams (PAR), composed of front line workers, managers and researchers, worked together to develop five scenarios that were based on actual exposure incidents. The exercises were tailored for different health care worker sub-groups, such as nurses, doctors and operating room staff. The exercises present factual risk assessment data, (such as the risk of infection with human immunodeficiency virus following a needlestick) as well as examples of barriers to compliance with safe work practices that health care workers might face in their everyday jobs. The exercises also present ways in which these barriers might be overcome.

The exercises were evaluated qualitatively through several pilot studies involving health care worker populations. A quantitative assessment tool that could be used in a pre/post test format has also been developed.

Because of the nature of the risk, and the relationship between the risk and the adoption of self-protective behaviors, simulation exercises may be a highly effective approach to limiting risk of exposure among health care workers. This approach might also be an effective method for targeting risk taking behavior with respect to a number of health care associated hazards, such as respiratory pathogens (e.g., not wearing respiratory masks), musculoskeletal injuries, (e.g., unsafe lifting), etc.

G5.3 Using a Narrative Simulation Exercise for Training Motorists to Avoid Collisions With Farm Machinery on Public Roads—Lehtola CJ, Cole HP, Bean TL, Piercy LR, Struttman T, Westneat S

The third leading cause of tractor-related fatalities is collisions with motor vehicles on public roadways. These deaths include tractor operators as well as motor vehicle occupants. Many motorists do not recognize the limitations of the tractor operator such as sight, hearing, and not being able to travel at high speeds. Motorists also may not be familiar with the meaning of the Slow Moving Vehicle emblem or the activation of turn signals vs. flashing hazard lights.

A simulation exercise was developed for the purpose of training "John Q. Public" motorist about the hazards posed by farm machinery on public roads. The exercise titled: "No Way To Meet A Neighbor" is an interactive story that presents an interesting but tragic scenario about a tractor and motor vehicle collision on a public road. The story is based on real incidents. The exercise is designed to help both farm and non-farm youth and adults become more aware of:

The risk of tractor and motor-vehicle collisions Strategies for avoiding collisions.

The use of ROPS and seatbelts prevent injury and death to tractor operators during even very severe tractor - motor vehicle collisions.

The exercise was developed in a workshop held at the University of Florida that included injury prevention specialists as well as university students involved in an agricultural safety class.

The exercise has been field tested in different locations in the country, including Florida, Ohio, and Kentucky. It has also been tested with a variety of age groups from pre-driving youth to adults. Answer sheets and questionnaires were returned for N=350. The data is being analyzed at the time of this abstract submission. Initial results indicate that for the adult sample the exercise appears to be both interesting and effective as a teaching activity.

G5.4 The Use and Impact of Narrative Simulations in the US Coal Industry—Vaught CV

This presentation will summarize the results of a recent study to assess how mine health and safety trainers used simulation exercises that were distributed (over a two year period) by the Mine Safety and Health Administration (National Mine Health and Safety Academy). The exercises are designed to teach judgment and decision making skills in three broad content areas: first aid, technical practices, and a mixture of the two. A previous study revealed that more than 400,000

response sheets were distributed prior to December 1994. The present study focused on who ordered the exercises (1995-1996), how the materials were used, and their impact on training. The sample size is 52 organizations. Safety and health trainers from these organizations reported that 31,785 workers were trained with the simulation exercises.

The presentation will condense and report on several aspects of the study. These include: exercise administration and evaluation strategies, perceived value of the simulations as training tools, and trainer suggestions for new materials. Overall, trainer responses to the survey suggested that the simulations helped to improve the effectiveness of their instruction and promoted a problem-solving approach to their training. The structure of their training also allowed them to make use of trainees' knowledge and experience. A large majority of the health and safety trainers responding to the survey offered to help in the construction and field-testing of new exercises.

The presentation will conclude with a few observations concerning continuation and expansion of the simulation exercises as one method for occupational health and safety training within the mining community. There were many collaborators in the construction and testing of the mine safety and health simulation exercises, and many are interested in extending those early collaborations.

G5.5 Using Case-based Interactive Narrative Simulation Exercises to Prevent Occupational Injuries—Cole HP

A series of interactive narrative simulation exercises was developed to empower workers and managers to recognize and remove risk factors for occupational injuries. The simulations are stories derived from actual injury and disaster cases. As workers select from among decisions alternatives at critical points in the exercises, they interact with the plots, characters, goals, and predicaments encountered in the story scenario as well as with each another as they collaborate in the decision making process. Research suggests four criteria for designing these types of problem-solving exercises. First, the narratives and decision alternatives must be accurate with respect to surveillance data that define injury events in terms of agents, hosts, risk factors, environments, exposure to specific injury agents, as well as the frequency and severity of these injury events. Second, the exercise narratives must be authentic with respect to the lives, culture, plights, context and language of the populations for whom the materials are designed. Third, the exercises are powerful teaching devices but also can serve as valid tools for assessing knowledge, attitudes, and behavior in situations like those depicted in the narratives. Fourth, the format of the exercises (paper and pencil, physical models, role play, computer, etc.) is not as important as the intent and coherence of the exercise narrative. Field tests of more than 100 simulation exercises in a wide variety of occupations provided information about the

problem-solving skills in which workers excel, the areas in which they need more education, the identification and correction of dangerous misconceptions, and areas in which the ability to work safely is compromised by poor work practices, poor equipment design, and the absence of adequate tools and resources. Worker performance data from the exercises can help management improve instruction, work organization, ergonomics, and engineering controls to reduced injury frequency and severity.

POSTER SOCIAL

PS.01 The Economic Impact of Occupational Fatalities, A Retrospective Study (1995-1998)—Beaulieu AM, Leighton RW, Lim KC, Richards RF

Background: Since 1991 the Maine Department of Labor (MDOL) in collaboration with the Federal Bureau of Labor Statistics began documenting occupational fatalities under the Census of Fatal Occupational Injuries (CFOI) program. The CFOI program record occupational fatalities under guidelines that identify the nature, part, source and event that led to that fatality.

Purpose of Study: The primary objective of the study is to determine the magnitude of the economic impact of fatal workplace injuries from 1995 through 1998 in Maine and how many of these fatalities were preventable.

Methodology: Using data from the CFOI and the Maine Workers' Compensation Board (WCB), the economic impact of 86 fatalities was assessed using indicators such as years of potential life lost, loss of future earnings, Workers' Compensation payments and OSHA penalties.

Results: The 86 fatalities accounted for 1,919 years of potential life lost study. The total sum of lost wages based on the retirement age of 65 not adjusting for inflation is estimated to be over \$1.3 million. Of the 86 cases, 29 (33.7%) cases had WCB death benefit payment, which totaled \$1.49 million and incurred \$170,857.00 in medical cost. Funeral cost accounted for \$198,071.00.

OSHA investigated 23 cases and levied fines totaling \$554,625.00. An analysis of 50 case reports by BLS Safety consultants indicated that 90.0% of these fatalities were preventable.

Discussion: Work-related fatalities present a significant economic impact to employers. Direct cost includes death benefit payments and medical expenses. Indirect cost includes lost of productivity due to disruptions at work, poor morale and OSHA fines. Long term impact includes the years of potential life lost and potential earnings. In addition, work-related fatalities have a significant impact on the quality of life of the families of the deceased workers.

PS.02 Measuring the Economic Burden of Occupational Fatal Injuries in the United States, 1990-1995—Biddle EA

Traumatic occupational injuries claimed the lives of over 30,000 American workers from 1990-1995 as reported through the National Traumatic Occupational Fatalities (NTOF) surveillance system. Fatalities represent the worst possible outcome for a worker and the highest burden to society. According to the National Safety Council, the median value of life lost to occupational fatality in 1997 was \$890,000. As with nearly all other studies, these losses are an aggregate value and shed no light on the variations in costs for differing worker characteristics or circumstances of the event. The ability to make these distinctions can aid in prioritizing efforts to prevent these devastating events.

Numerous theoretical models to measure the cost of occupational fatalities to society have been developed. The cost of illness method is the most commonly adopted approach for legal proceedings and formal policy analyses. This method is divided into two components, direct and indirect costs. Direct costs are actual dollar expenditures associated with the fatality while indirect cost is the value of lost output due to decreased productivity. The value of productivity losses can be calculated using a Human Capital approach by determining the present value of a future stream of output valued at market earnings.

This project developed a user-friendly computer program to calculate the Human Capital cost of fatal injuries reported through NTOF. The model provides comprehensive national estimates for the economic burden of all occupational fatal injuries and specific estimates for the burden on selected groups (e.g., specific industries, occupation groups, and teenage workers). Finally, this model provides an additional reliable basis, economic risk, for targeting and evaluating the effectiveness of investments in prevention of occupational fatalities.

PS.03 The Practicality of Using Fault Tree Analysis to Improve Mine Safety—Kerkering JC, Coleman P, Beus M, Iverson S, Stewart W

Many mining safety research projects are multi-faceted. It is therefore difficult for management and researchers to determine where to focus their research efforts. Fault tree analysis may provide an effective tool.

Fault tree analysis is a systematic safety analysis tool that proceeds deductively from the occurrence of an undesired event (accident, injury, equipment malfunction) to the identification of the causes of that undesired event. Bell Telephone Laboratories first used this tool in the 1960s. The aerospace and nuclear industry then successfully adopted it to enhance the safety of their operations. These early

applications, however, required large computers and expensive software and were on predominantly deterministic, static, closed systems quite unlike the open-ended and ever-changing work environment encountered in mining. Our research explored the feasibility of extending fault tree analysis to the dynamic mine environment. One recurring mine safety problem, the blockage of an ore pass, was analyzed using a currently available and inexpensive fault tree program on a personal computer. The analysis identified basic and intermediate events that led to the failure of the ore pass; it graphically depicted the interrelationship between these various subordinate events as well as the various cut sets and the minimal cut set (all members are necessary for the occurrence of the top event). Focus groups were used to estimate relative probabilities of occurrence for each of the basic events. A sensitivity analysis on these probabilities showed the basic events (wrong ore-size to grizzly-opening ratio, excessive moisture or finer content) having the greatest influence on ore chute blockage. This suggests these events should be first addressed in a program of safety research designed for most efficiently preventing the ore chute blockage. This research shows that it is feasible with personal computers and inexpensive software to use fault tree analysis to improve mine safety.

PS.04 The Economic and Social Impact of Work-Related Carbon Monoxide Poisoning—Chenoweth BA, Lim KC, Nadeau MR, Roy JC, Surette RI

Background: The Maine Workers' Compensation Board (WCB) reported an average of eight cases of carbon monoxide (CO) poisoning per year (1994-1998). In 1999, the Maine Department of Labor (MDOL) received reports from the Maine Agricultural Safety and Health Program (ASHP) of two incidents where twenty-two workers required medical treatment. One incident occurred at a plant where workers were exposed to CO from propane-powered forklifts. The other involved workers using propane-powered floor buffers.

Purpose of Study: The objective of this study is twofold: 1. Demonstrate to employers the benefits of the MDOL "SafetyWorks" program, which offers training to employees to recognize and prevent CO poisoning, at no cost to employers. 2. Develop a generic research protocol to assess the economic and social impact of work-related injuries.

Methodology: The sample (n=39) consisted of 1998-1999 cases of CO poisoning from the databases of the WCB and the ASHP. Medical cost indicators such as the use of a hyperbaric chamber measured the economic impact of these cases. Other cost indicators included loss of income and OSHA fines. The injured workers were interviewed by telephone to assess any social impact of these injuries.

Results: Of the 39 cases investigated, medical costs for 33.3% of these cases were not available because no Workers'

Compensation claims were filed. The total medical cost for twenty-four cases was \$35,230.00. Other economic indicators were indemnity payments from the WCB and OSHA fines. Seventy-one percent of those interviewed reported no prevention training was provided following their CO exposure.

Discussion: The data demonstrated that the benefits of the MDOL "SafetyWorks" outweigh training costs (time away from work) incurred by employers who send their employees to CO poisoning prevention training. The study also showed that research on the economic impact of work-related injuries could not be systematically collected under the current system.

PS.05 Integrating Injury Research With Industry Experience to Develop Measures for Preventing Worker Injuries From Vehicles and Equipment in Highway Work Zones—Fosbroke DE, Pratt SG, Burkhart JE, Marsh SM, Casini VJ, Moore PH, Smith GJ,

Highway workers are exposed to injury from moving construction vehicles and equipment within the work zone and from motor vehicle traffic passing through the work zone. Census of Fatal Occupational Injuries (CFOI) data indicate that of the 600 work-related fatalities in the U.S. highway construction industry between 1992 and 1996, 328 (55%) were vehicle or equipment-related incidents that occurred in a work zone. Historically, prevention has been based on the premise that worker injuries are minimized when work zone traffic collisions are minimized. However, only half of the vehicle-related fatalities among highway workers involve a motorist.

To better understand highway worker injury risks, NIOSH reviewed current highway safety literature, analyzed worker fatality data, investigated selected fatalities, and held a workshop with government, labor, industry, academia, and State transportation departments. Workshop participants were asked to discuss measures that would reduce or eliminate hazards to highway workers. By bringing together people with diverse interests in work zone safety, NIOSH hoped to improve our understanding of the hazards faced by highway workers, raise the industry's awareness of these hazards, and initiate discussion about hazard reduction measures. The resulting NIOSH document outlines specific measures that contractors, contracting agencies, policy makers, manufacturers, law enforcers, and researchers can take to reduce occupational injuries in highway work zones. Though the efficacy of this intervention has yet to be evaluated, the development process is a model of how to develop pragmatic recommendations by combining injury research with industry experience.

PS.06 Pilot Study of Transient Risk Factors for Sharps-Related Injuries in Health Care Workers—Fisman DN, Harris AD, Sorock GS, Gordon K, Brandt G, Mittleman MA

Healthcare workers in the USA sustain approximately 400,000 injuries annually, due to needles and other sharp devices. Such injuries are associated with the transmission of HIV and hepatitis C. Although some factors, such as the use of gloves, modify the risk of sharps-related injuries, little is known about the potentially modifiable circumstances leading to such injuries. This is largely due to the methodological limitations of traditional case-control and cohort studies in the assessment of risk associated with repeated, transient exposures. We therefore designed a case-crossover study to evaluate the risk of sharps-related injuries associated with brief, transient exposures, including rushing, fatigue, and the provision of emergency care. Case-crossover methodology, which uses each subject as his or her own control, was developed specifically to evaluate the effects of transient exposures on the immediate risk of injury or disease occurrence. The study involves two large teaching hospitals: University of Maryland Medical Systems, in Baltimore, and Beth Israel Deaconess Medical Center, in Boston. Recruitment of subjects has been facilitated through multi-disciplinary collaboration of injury epidemiologists with the hospital employee health services and infectious diseases services that oversee management of sharps-related injuries. Informed consent for interview is obtained at the time of management of the injury.

Consenting subjects participate in a telephone interview. Twenty subjects were recruited in the preliminary phase of the pilot study. Employees, trainees, and students have been enrolled, and it has been possible to contact 18 of twenty subjects within 3 days of injury reporting. The questionnaire used has permitted assessment of injuries sustained in surgical and non-surgical work environments. Participant response to the questionnaire has been favorable. Our preliminary experience with this multi-center pilot case-crossover study suggests that this methodology provides a feasible means of assessing brief, transient exposures as risk factors for sharps-related injuries in healthcare workers.

PS.07 Impact of a Changing U.S. Workforce on the Occupational Injury Experience, 1980-1994—Hartley DL, Biddle EA

The civilian labor force has increased considerably over the past quarter century—due in part to rapid population growth and an increasing retirement age. According to the Bureau of Labor Statistics projections, the number of older workers will increase by 48% between 1998 and 2008, from 17 million to 25 million workers.

Between 1980 and 1994, workers aged 65 years and older had the very highest workplace injury death rates—3 times the rate

for other workers. The National Traumatic Occupational Fatalities Surveillance system reported 6,471 fatalities of civilian workers aged 65 years and older. The number of all fatalities has decreased over time, but the proportion of older worker fatalities has increased—ranging from a low of 6% of all work-related fatalities in the early 1980's to 8% in 1994.

Characteristics of older worker fatalities during 1980-1994, suggests that interventions need to focus on those who work in agricultural settings, who work around or operate machines, and who are exposed to fall hazards and risk factors for violence. Past fatality experience and projected employment patterns can be analyzed together to better understand the impact of an aging workforce on occupational safety and health.

PS.08 Five Workers Engulfed & Suffocated in Corn in Nebraska, 1999—Hetzler WE

Background: In Nebraska, where corn production is the second highest in the nation, the land is dotted with grain bins, gravity feed bins and gravity feed wagons. When workers enter these bins and wagons they can become engulfed in corn and suffocate. In the United States, between 1980 and 1994, over 120 people (NTOF reported 88 deaths from 1980 to 1992 and CFOI reported 33 deaths from 1993 to 1994) were killed by grain engulfment.

Purpose: To identify and describe trends in grain engulfment fatalities and disseminate preventive strategies to those who can intervene in the workplace.

Methods: Nebraska entered into a cooperative agreement with NIOSH in 1994. Using protocols developed by the NIOSH FACE program, corn engulfment cases were identified and on-site investigations were conducted. Using the Haddon model, investigators were able to identify multiple causes and develop multiple prevention strategies to help prevent similar types of deaths.

Results: Five cases were identified. Three cases involved entry into corn bins; one case dealt with a bin that burst, burying the victim, and another case involved a semi grain hopper engulfment.

Conclusions: Recommendations to prevent future similar fatalities include complying with national safety standards, installing locks on access doors to bins and silos, and equipping workers with two-way communications equipment. To disseminate the recommendations, the NE FACE program developed a FACE FACTS sheet that summarized these cases and detailed the prevention recommendations and collaborated with the Omaha and Nebraska Safety Councils who distributed 2,500 FACE FACTS to businesses throughout Nebraska and Western Iowa. This poster will also be presented to the regional meeting (Iowa, Nebraska, Colorado and Kansas) of Farm Safety 4 Just Kids, in June, 2000. The

FACE FACTS sheet was placed on the NE FACE website and numerous presentations were given to the Nebraska agricultural community.

PS.09 Fatality Assessment and Control Evaluation (FACE) Program: Recommendations for Preventing Injuries and Deaths of Workers Who Operate or Work Near Forklifts—Higgins DN, Braddee RW,

Background: Forklifts, also known as powered industrial trucks, are used in numerous work settings, primarily to move materials. Each year in the United States, nearly 100 workers are killed and another 20,000 are seriously injured in fork-lift related incidents [BLS 1997, 1998].

Purpose: To identify and describe trends in forklift-related fatal incidents and to use data collected in fatality investigations to formulate and then disseminate preventive strategies to those who can intervene in the workplace.

Methods: Data from the National Traumatic Occupational Fatalities (NTOF) data base are used to describe trends and rates of fatalities over a 15 year period. It is estimated that NTOF, which is based solely on death certificates, identifies about 80% of work-related deaths. Through investigations done in the Fatality Assessment and Control Evaluation (FACE) program, additional characteristics such as safety practices, standards, and equipment are detailed. Through surveillance and investigations, potential risk factors are identified and prevention strategies are developed.

Results: From 1980 to 1994, 1,021 workers died from traumatic injuries suffered in work-related incidents that involved forklifts. The majority of these deaths were due to forklift overturns (22%), workers struck by forklifts while working nearby (20%), victims crushed by forklifts (16%), and falls from forklifts (9%). Between 1983 and 1999, the NIOSH FACE program investigated 13 fatalities that involved workers who died as a result of forklift injuries.

Conclusions: Recommendations include working in compliance with national safety standards, establishing and implementing written safe work procedures, retrofitting roll-over protective structures and seat belts (where applicable), and providing appropriate worker training.

PS.10 Eye Injury Prevention Among Mechanical Contractors—Hsu L, Hunting KL, Welch LS

A survey on eye injury prevention was distributed to approximately 2000 mechanical contractors; 171 completed surveys were received. Each contractor reported the number of eye injuries during 1998 which required first aid or medical care. The aggregate eye injury rate (total) was 4.6/100 workers. Rates varied by size of contractor and the type of work done by the contractors.

A substantial number of contractors had high quality eye injury prevention programs. Almost all contractors required workers to use eye protection either all the time or for specific tasks. Some companies reported strict enforcement mechanisms for these requirements, while other companies relied primarily on frequent reminders to workers. Many contractors mentioned that motivating employees to wear eye protection was their biggest challenge, but others reported successes from supplying comfortable, high quality, stylish safety glasses, including such features as anti-fog coatings, shaded lenses, and lanyards.

Almost all contractors provided eye protection training. Training generally covered eye injury hazards and prevention, but a minority of training programs focused on selecting and fitting appropriate eyewear. For about two-thirds of the contractors, the “standard” eye protection was safety glasses with side shields; the remainder relied on unshielded safety glasses. For instance, many eye injuries occur during overhead work; top and side shields are needed to prevent these injuries. Thus, a key issue for prevention is whether the type of eye protection worn is sufficiently protective for the task being performed.

It was somewhat surprising to find that contractors with a more comprehensive eye injury prevention program did not have a lower rate of eye injury. However, high quality eye injury programs and higher injury rates may identify companies which work under high-risk conditions. To see if prevention programs work, company specific rates must be evaluated before and after implementation of eye injury prevention programs.

PS.11 Work-related Acute Eye Injuries Presenting to the West Virginia University Hospital Emergency Department—Inman CJ, Jackson LL, Helmkamp JC, Islam SS, Furbee PM

Background: Over 600,000 work-related eye injuries occur annually. This number may be low because clinical recognition and surveillance mechanisms to accurately characterize occupational injuries are lacking.

Methods: To develop a better understanding of occupational eye injury circumstances and under-reporting of work-related injuries, we examined all emergency department (ED) visits for an eye injury presenting at West Virginia University Hospital Emergency Department during 1996. Through the emergency department-based injury surveillance system (EDBISS), we identified 556 eye injury visits. Medical charts were reviewed for injury circumstances and work-relatedness—defined as any injury or illness incurred while doing work for compensation, all agricultural production activities, and while doing work as a volunteer for an organized group.

Results: On the basis of chart review, we identified 326 first visits for patients 18 years and older with an eye injury: 98 were work-related, 184 were non-work related, and 44 were possibly work-related. Based on admissions information, EDBISS indicated that 90 visits were work-related of the 98 cases identified from chart review ($\text{Kappa}=90\%$). Since there were other misclassifications regarding work-relatedness and possible work-relatedness this kappa value may be an over estimate. From chart review, 69 cases filed West Virginia Workers Compensation claims. Of these, 54 (78%) were matched with the West Virginia Workers Compensation database which captures all work-related injuries in the state except voluntary organizations and churches. We are exploring reasons for the low match rate by comparing the matched and unmatched cases with regards to severity of injury and occupation.

Conclusions: Injury surveillance that relies on compensation or insurance providers may under-report occupational injuries as seen in this example. Injury prevention would benefit from improved recording of work-related details by ED staff

PS.12 Occupational Homicide and Non-facility Based Workers—Johnson RM, Loomis D, Wolf S, Gregory E

About 12% of all fatal occupational injuries are homicides (1,2), homicide is recognized as a problem in occupational safety (3-7). Non-facility based [NFB] workers, specifically taxi-cab drivers, have high rates of homicide relative to other workers (3,5,8). The risk of homicide for other NFB workers is less clearly understood than the risk for taxi-cab drivers. However, because such workers are often exposed to a number of risk factors for occupational homicide (e.g., exchange of money with the public, working late-night or early-morning hours, working in community settings, working alone), it is important to examine their risk for homicide.

The data for this poster come from Dana Loomis’s occupational homicide in North Carolina case-control study (n=152). The goals of these analyses are to (1) evaluate the risk of workplace homicide for NFB workplaces compared to other workplaces, and to (2) evaluate factors potentially associated with NFB workplace homicide (e.g., such as typical duties, hours worked, training, protocol for robbery situations). To address the first goal, we will compare the homicide rates among the two categories of workplaces. For the second goal, we will examine exposure to risk and protective factors for occupational homicide restricting analyses to the 69 workplaces with NFB workers. Case workplaces (n for NFB workplaces=23) include those in which a worker was killed while on duty, and were identified through the North Carolina medical examiner system. Control workplaces (n for NFB workplaces=46) were sampled randomly from state businesses and agencies contained in “American Business Lists”. We administered a questionnaire to collect detailed information on workplaces, the demographic

characteristics of their employees, and an array of factors potentially related to the risk of workplace homicide. Descriptive statistics will be presented in detail. Odds ratios and 95% confidence intervals will be generated using conditional logistic regression.

PS.14 Perceived Postural Sway and Discomfort During Simulated Drywall Lifting and Hanging Tasks—Long DJ, Pan CS, Chiou SS, Skidmore PO, Zwiener JY

This study identified the perceived postural sway and discomfort experienced by construction workers performing simulated drywall lifting and hanging tasks under laboratory conditions. Sixty construction workers (mean age = 34.4 ± 8.5 years) with at least 6 months of installation experience (mean experience = 8.7 ± 6.1 years) participated in this study. From a previous field study, four methods each for the tasks of lifting and hanging drywall were identified. Participants were assigned in random order to one lifting and one hanging method. Subjects then performed four replications of the assigned lifting and hanging methods. To determine subject perception of postural instability and whole body discomfort, participants were verbally asked a questionnaire at the completion of each replication. An ANOVA with repeated measures was performed to determine which, if any, of the lifting or hanging methods were perceived by subjects as causing significantly more postural sway or discomfort.

For the hanging tasks, the horizontal hanging of drywall onto a wall was perceived as causing significantly more postural sway and discomfort than the horizontal hanging of drywall onto a ceiling ($p < .05$). Horizontal hanging of drywall onto a wall was also perceived as causing more discomfort than the vertical hanging of drywall onto a ceiling ($p < .05$). Among the four lifting tasks, there were no significant differences perceived by subjects for either postural sway or discomfort.

This study provides subjective balance measures for drywall lifting and hanging tasks. These results, when combined with parallel studies on kinetics and kinematics as well as the field studies, will allow recommendations for the safest lifting and hanging methods for reducing fall injuries.

PS.15 Causes of Electrocutions Among Construction Workers—McCann MF, Chowdhury RT

This paper analyzes the causes of electrocutions among construction workers, based on Census of Fatal Occupational Injuries (CFOI) data for the years 1992 through 1997. The 836 resulting fatalities were divided by occupation into two categories: 268 electrical workers (electricians and apprentices, electrical power installers and repairers, and their supervisors); and 568 non-electrical workers, comprising all other construction occupations.

Contact with overhead power lines caused the electrocution of 34% of the 268 electrical workers, and 53% of the 568 non-electrical workers. For purposes of this paper, electrocutions due to overhead power lines, buried, underground power lines and lightning were excluded, since there have been previous studies on these topics. The remaining electrocutions were then divided into several categories.

Contact with electrical equipment (wiring, light fixtures, and other electrical parts such as circuit breakers, transformers, control panels and junction boxes) comprised 50% of all electrical worker electrocutions, but only 19% of non-electrical worker electrocutions. Contact with metal objects that became energized by contact with live electrical circuits and parts caused 9% of electrocutions of electrical workers and 8% of non-electrical workers. Analysis of the CFOI narratives indicated that working “live” or near live electrical circuits and parts was the major cause of these fatalities.

Contact with appliances or machinery caused 4% of the electrocutions of electrical workers and 6% of non-electrical workers. Power tools and portable lights caused 4% of the electrocutions of non-electrical workers. Defective power cords and extension cords were major contributing factors in many of these electrocutions.

Other contributing factors to these electrocutions included working in cramped spaces (such as attics, above drop ceilings, basements and under houses), and worker or equipment (such as portable lights or extension cords) contact with water. Contact with household voltage (120/240 volts) was involved in at least 13% of all electrocutions.

PS.16 An Analysis of Falls by Construction Type Among Construction Workers—McCann MF, Chowdhury RT

This paper analyzes 364 fatal falls to a lower level among construction workers, based on Census of Fatal Occupational Injuries (CFOI) data for 1997. Nine records were excluded from the study because they involved falls prior to 1997 with the deaths occurring in 1997. The most frequent trades involved were construction laborers (27%), roofers (11%), carpenters (10%), and structural metal workers (9%).

The fatal falls were classified into several categories of construction type based on the industry field, location field, and narrative of the CFOI records. The percentage of total falls by the various construction types selected were: residential (one-family home or townhouse) — 17%, non-residential building — 59%, unspecified building — 10%, other than building — 9%, and unknown - 4%.

Several differences were apparent in the types of falls for residential and non-residential buildings. Falls from or through roofs were similar (35% of all residential falls vs. 39% of all non-residential building falls), as were falls from scaffolds

(16% each). The percentage of falls through floor openings was higher for residential compared to non-residential buildings (10% vs. 3%), as was the percentage for falls from ladders (32% vs. 14%). Residential construction had no fatal falls from aerial lifts, while 6% of fatal falls from non-residential buildings were due to aerial lifts. These differences probably are due to differences in construction methods.

Fatal falls involving self-employed workers also differed by construction type. Overall, 17% of total fatal falls involved self-employed workers, comparable to the percentage of self-employed workers in the construction workforce. Residential construction was responsible for 43% of the fatal falls of self-employed workers, while non-residential building construction was responsible for 11% of self-employed fatal falls. These figures might reflect the greater number of self-employed workers involved in residential construction.

PS.17 Work-related Injury Among California Migrant Hispanic Farm Workers—McCurdy SA, Beaumont JJ, Wilson BW, Henderson J, Samuels SJ, Schenker MB, Morrin L, Carroll D

Objectives: To evaluate injury experience through a harvest season among migrant Hispanic farm workers. Study hypotheses include piece-work vs. hourly pay, and the role of multiple employment.

Methods: We conducted a prospective cohort study of injury across the 1997 harvest season among migrant Hispanic farm worker living in local migrant family housing centers. Participants completed an initial interviewer-administered work-and-health questionnaire with periodic followup during the season.

Results: One-thousand two hundred and six adult farm workers completed the initial survey. Participation rates in participating housing centers ranged from 82%-95%. Eight hundred thirty-nine persons (69.6%) completed the fourth and final periodic questionnaire. There were 96 occupational and 44 nonoccupational injuries observed over the harvest season or reported for the preceding year, yielding a one-year reported occupational injury rate of 10.4/100 FTE. Increased risk was noted for men (11.0 vs. 9.2/100 FTE for women) and current smokers (14.1 vs. 9.0/100 FTE for never-smokers). Sprains and strains were predominant, comprising 29 (30%) occupational injuries, followed by lacerations, comprising 14 (15%) occupational injuries. The most commonly involved body parts were the head (28%) and trunk (26%). Overexertion and strenuous movements were the most common external cause, comprising 26 (27%) occupational injuries.

Conclusions: Quantitative injury risk for this cohort appears comparable to that of agricultural workers in other U.S.

settings. Results addressing a priori study hypotheses will be discussed at the conference.

PS.18 Do Complaints Take OSHA to Less Risky Workplaces?—Mendeloff JM

In many years, more than half of OSHA's inspections in general industry are triggered by complaints from workers or their representatives. There has been considerable controversy about whether responding to these complaints represents a good use of OSHA's resources. Critics have argued that complaints to OSHA are often tools used as part of unrelated labor-management conflicts.

The research reported here examines whether the work places that receive "complaint inspections" are less hazardous (as measured by injury rates from the OSHA logs) than workplaces that are not inspected or that are subjected to "planned inspections."

We used the 1995 OSHA Data Initiative, which collected OSHA logs from 80,000 establishments in manufacturing and a few other industries. All establishments had at least 60 employees. These data were merged with OSHA's data file on inspections.

We examined the results for the 94-digit SICs with the largest number of establishments. Overall, we found that the average injury rate was higher at workplaces with complaints (7.39 per 100 workers) than at those with planned inspections (6.80) or with no inspections (5.98). The same pattern was found when we looked within each of the 4-digit industries and within size groups within them. In addition, we found that, for complaint inspections, the number of serious violations cited was significantly and positively correlated with the injury rate, relative to the industry and size group average.

These data do not support the view that complaint inspections tend to take OSHA to workplaces with minor injury problems.

PS.19 Occupational Fatalities Associated With Harvesting and Handling Large Bales-United States, 1980-1998, Minnesota FACE, 1993-1999, Oklahoma FACE, 1995-1999—Parker DL, Wahl GL, Douglas MR, Mallonee S, Archer PJ

The agriculture industry has one of the highest occupational fatality rates of all U.S. industries. Nationally, the Census of Fatal Occupational Injuries (CFOI) identified 65 work-related fatalities associated with harvesting and handling bales in the United States during 1992-1998.

Since the mid-1970's traditional small forage balers have gradually been replaced by large balers in the agricultural industry. While the harvest and handling of small bales exposed workers to hazards, harvesting and handling large

bales weighing between 1,000 and 1,500 pounds exposes workers to new hazards.

The National Institute for Occupational Safety and Health (NIOSH) State-based Fatality Assessment and Control Evaluation (FACE) program conducts research designed to identify and study factors that increase the risk of fatal occupational injuries. The goal of the FACE program is to prevent occupational fatalities across the nation by identifying and investigating work situations at high risk for injury and then formulating and disseminating prevention strategies to those who can intervene in the workplace.

This poster summarizes large bale case investigations conducted by the Minnesota FACE (MN FACE) program during 1993-1999 and the Oklahoma FACE (OK FACE) program during 1995-1999. During 1993-1999, MN FACE investigated 11 incidents (4 tractor rollovers, 3 entanglements, 2 struck by and 2 caught between) and OK FACE investigated 2 entanglement incidents associated with harvesting and handling large bales. In three of the five entanglement cases, fires developed within the balers.

The MN FACE and OK FACE program investigations resulted in the development of specific safety recommendations to reduce the risk of fatal injury associated with harvesting and handling bales. These recommendations focus on the use of appropriate machinery, proper machine operation and maintenance, availability of fire fighting and communication equipment, and using tractors equipped with a rollover protective structure and a seat belt.

PS.20 Injury Surveillance Using Existing Workers' Compensation Medical Claims Data—Peele PB, Stockman CK, Tollerud DJ

The routine processing of workers' compensation medical claims for injured workers creates a rich database of information about workplace safety. Few, if any, employers currently take advantage of the existence of these data to monitor workplace injuries. The goal of this research is to improve the welfare of employees by providing employers with explicit guidelines for using their medical claims data to monitor workplace safety and to evaluate safety programs.

Workers' compensation medical claims data for the 29,000 FTE employees of the City of Philadelphia for the years 1994-1997 supply the basic dataset for developing monitoring techniques. Using only these data, we construct weighted variables capable of rapidly capturing the number and severity of injuries. These are benchmarked to injuries in previous years and mapped over time to offer employers an ongoing surveillance window to observe changes in workplace safety. Additionally, we estimate the under-reporting of injuries that necessarily occurs when only medical claims data are used to count injuries. This is done by tracking the gap between all

reported injuries and injuries receiving formal medical treatment.

Because most workplace injuries result in very short courses of medical treatment, we find this system to be both feasible and reliable for monitoring workplace safety. Importantly, this novel injury surveillance system does not require any additional data collection by employers. Hence it is a low-cost, easily implemented surveillance/monitoring system that would alert employers to changes in workplace safety, allowing them to intervene early when signs of safety degradation appear. The study population for developing this system is a large municipality, but given the similarity of labor mix across municipalities, these results are immediately and directly applicable to other municipalities. In addition to other municipalities, we expect our guidelines to have direct application for many other large employers as well.

PS.21 ICD-9-CM vs. ICD-10 for Coding Occupational Fatalities: Is ICD-10 Better, Worse, or Just Different?—Pope MJ, Reed DK

The International Classification of Diseases (ICD) is used extensively for coding occupational injury and fatalities. The widely used ninth revision, clinical modification, commonly referred to as ICD-9-CM, is gradually being replaced with the tenth revision, or ICD-10, which was released in 1992. Although an ICD-10-CM has also been developed, its implementation isn't expected to be until after 2001. Mortality data from death certificates has been recorded using ICD-10 since January 1, 1999. This study addresses how the new coding will affect those who rely on ICD codes to track and evaluate workplace fatalities.

The Fatality Assessment and Control Evaluation (FACE) project (funded by NIOSH) at the Kentucky Injury Prevention and Research Center (KIPRC) has tracked occupational fatalities in the state since its inception in 1994. Currently more than 800 fatalities are included in a database of general information that contains ICD-9-CM codes for the cause of death. In preparation for the change to ICD-10, cases were re-coded and the resulting code definitions were compared to the previously coded ICD-9-CM code definitions to determine the effects of the change. This presentation will show the perceived benefits and deficits of the "new" coding system as it relates to actual occupational fatality cases.

PS.22 Fatal Incidents Involving Farm Equipment on Public Roadways—Reed DK, Struttman TW

Data linkage of the Fatality Analysis Reporting System (FARS) and the Fatality Assessment Control Evaluation (FACE) for occupational fatalities in Kentucky revealed agriculture as the second highest Industry and Occupation for work-related roadway fatalities in Kentucky from 1994-97.

Farm equipment on public roadways pose a hazard to not only the operator but also the rural driving population. Between 1994-97, there were 430 fatal motor vehicle crashes (MVC) involving farm equipment on US roadways. California, Wisconsin, Kentucky, Texas, Indiana, and Minnesota lead the nation in number of fatal MVCs involving farm equipment.

Based on the number of farms in each of these states, the leading states were California, Indiana, and Wisconsin. Rates per 10,000 rural roadway miles were 30.7 for California, 21.32 for Wisconsin, and 20.91 for Indiana. Based on the number of wheeled tractors per farm, the leading states were California, Texas, and Kentucky. Kentucky had the most incidents per 1,000,000 licensed drivers with 7.95; Minnesota had 6.97/1,000,000; and Indiana 5.03/1,000,000.

From the 430 fatal MVCs, 281 cases involved farm equipment vs a motor vehicle in transport. In 51.6% of these cases, the farm equipment driver was not injured. 30.6% of the farm equipment drivers were killed. This suggests the driver and passengers of a motor vehicle in such an incident are in danger of losing their lives. Over half of these incidents involved a motor vehicle rear-ending the farm equipment. Interventions must focus on all rural drivers as well as farmers.

PS.23 A Cost Model for Traumatic Injuries in Mining—
Sacks HK, Pana-Cryan R

A cost model for traumatic injuries in mining has been developed as a tool to assist in focusing injury prevention research. Assigning a relative cost to an injury event provides a useful method for ranking research projects. It also provides compelling evidence for employers and employees to invest in preventative measures. The starting point for the model is the Mine Health and Safety Administration's (MSHA) injury and illness database. The database provides information on the victim's age, occupation, injury severity and time lost from work. The model, based on a societal perspective, calculates lost earnings and non-market loss (also known as home production) as a proxy for lost production. It also calculates medical costs. Earnings are derived from union contract data and commercial wage surveys. Future earnings estimates are adjusted for the employment cost index, discount rate, and life cycle salary growth. Medical costs are based on the days lost from work and the degree of injury. Aggregated data from the National Council on Compensation Insurance (NCCI) detailed claims information reports were analyzed. The analysis showed that medical costs are linearly related to days lost and benefit class. The model assigns a cost to each lost time injury in the MSHA database.

PS.24 Experiences of Widows Following a Farm-related Fatality—
Scheerer A, Brandt V

Farming families have been identified traditionally with a strong family bond resulting from both living and working

together. When a farming fatality occurs, surviving family members are left to deal with not only the tragedy of losing a loved one, but also the loss of a coworker. The stress confronting farming families may contribute to serious consequences for their business, their relationships with each other, and the mental health of the individual members. These issues were explored through in-depth personal interviews with farming widows in Kentucky.

Families who experienced a farming fatality were identified through the Kentucky Fatality Assessment and Control Evaluation (FACE) Project, a statewide surveillance system for occupational fatalities. Eligible candidates for interviews were families in which the death had occurred between one and five years prior to the interview (1994-1998). Interviews with seven widows were selected for analysis. NUDIST software was used to organize and code the data into meaningful themes and groups.

Similar themes were found among the respondents as they described the consequences of the fatality on their family and business. Economic issues were an underlying consideration in many aspects of their experience. Even though none of the widows lost their farm or home because of financial difficulties, they did make changes in the amount or type of commodities so that it was manageable without hiring outside help. To maintain income, it was necessary to continue with chores such as caring for livestock and tending to crops which left little time for personal bereavement. Respondents discussed the changes in their farm and family, their coping mechanisms and support systems. In developing resources for families in similar circumstances, it is important to understand how intertwined their lives are with the farm environment and economics of the business.

PS.25 Injuries Relating to Tobacco Farming in Kentucky—
Struttman TW, Caudill D, Reed DK

Agriculture is one of the most hazardous occupations in the United States. Although the investigation of agricultural injuries by segmenting a particular commodity is not new, none have concentrated on tobacco production. In 1997, tobacco production in the U.S. was reported at 1,747,702,321 lbs. Kentucky produced 30.4% of this on over half its 82,273 farms.

Tobacco farming is labor intensive, involving several phases of production, each exposing the farmer and farm family to different modes of injury. In two agricultural regions, 2,911 agricultural injury cases were identified through emergency departments between 1992 and 1999. Of these cases, 703 were related to tobacco production.

Analysis of the tobacco injuries shows the median age was 31 years. More than half of the injuries occurred in August and September. Falls were the leading cause of injury,

comprising 27.1% of the total. Injuries from edged/piercing instruments were next with 24.3%. Seventeen percent of the injuries were to children under 18 years. There was an increase in the number of Hispanic workers, from 3% in 1992 to 14% in 1999. There were five fatalities, three of which were from tractor overturns. The mean hospital charge was \$489, with a median of \$213 and a range of \$8 - \$25,778.

This descriptive study can be used in the development of appropriate prevention strategies for tobacco production. Many of the injuries sustained to the upper and lower limbs were due to the tobacco spears used during the harvest. These injuries could be avoided by using leather chaps on lower legs and leather gloves with gauntlets for the hands. Falls from height could be reduced by using single-story barns or curing structures such as post-row frameworks. Prevention measures must also focus on migrant workers that are affected by language and cultural barriers.

PS.26 California Fatality Assessment and Control Evaluation (FACE): Summary of Occupational Fatalities in Los Angeles County 1992-1998—Styles LE, Tibben R, Harrison R, Gillen M, Fowler J, Guerriero J

The California Department of Health Services, in collaboration with the National Institute for Occupational Safety and Health (NIOSH), has established the California Fatality Assessment and Control Evaluation program (FACE) for the surveillance and investigation of workplace fatalities. The FACE program seeks to link multisource reporting of fatal occupational injuries with timely investigations to identify work-related risk factors, make recommendations for preventing fatalities, and facilitate workplace prevention programs. Preliminary results from 1992-1998 show that the leading cause of occupational fatalities in Los Angeles County was homicide (42%), followed by transportation-related (15%), crushed/compressed/struck by/caught in (12%), falls (12%), electrocution (5%), fire/explosion (3%), other (10%). This presentation will summarize the demographics and the industry and occupation of those who died at work. Investigated deaths will be highlighted and specific recommendations to prevent similar deaths will be discussed.

PS.27 Epidemiology of Occupational Injury Among Cooks—Velilla AM, Islam SS, Syamlal G, Ducatman AM

Several studies have shown cooks to have a greater risk of burn injury compared to other occupations. However, epidemiological characteristics of other work-related injuries among cooks are not well documented. Using a state-wide workers compensation database, the epidemiological characteristics of work-related injuries among cooks were described. During a four-year study period (1995-1998) there were 213,111 compensable injuries, 6130 (2.9%) of which were among cooks. The most common injuries among cooks were laceration (30%), sprain (28%), and heat burn (15%). However,

when compared to other workers, cooks were found to be at higher risk of heat burns, lacerations, and chemical burns (RR 7.7, 1.9, and 1.6 respectively). Of the injuries among cooks, 58% occurred in females and 42% in males. Female cooks were significantly older than male cooks (mean age 41.7 vs. 26.8 years). A greater proportion of cooks (52%) earned lower weekly wages at the time of injury (\$200 or less) compared to other workers (19%). In contrast to other occupations where women are the lower wage earners, among cooks lower wage earners are predominantly male. The risk of injury to cooks also varied by age category. Adolescent cooks (age 14-19 years) had a higher risk of compensable injury (RR 2.6) compared to other adolescent workers. This study shows that work-related injuries among cooks are significantly different from other occupations and as such, require targeted intervention strategies to reduce injuries.

DAY THREE—THURSDAY, OCTOBER 19, 2000

Session: H1.0 Title: Vehicle-Related Transportation Fatalities in the Workplace: Research and Prevention Strategies

Category: Special Session
Organized by Stephanie Pratt, National Institute for Occupational Safety and Health
Moderator(s): Roger Rosa

H1.1 Occupational Pedestrian-Vehicle Collision Fatalities in the United States, 1992-1997—Strotmeyer SJ, Pratt SG

Motor vehicle-related injuries are the leading cause of occupational fatalities. The majority of research has focused on collisions between vehicles and single-vehicle events, with relatively little attention to pedestrian fatalities, reported to be 14% of traffic-related occupational fatalities.

We describe the trends, magnitude and pattern of fatal vehicle-related injuries to pedestrian workers in the U.S. during 1992-1997.

Data from the Census of Fatal Occupational Injuries (CFOI) were analyzed to tabulate frequencies, fatality rates, and to investigate event characteristics associated with the occurrence of these fatalities. The Bureau of Labor Statistics maintains CFOI, a multiple source surveillance system.

Between 1992-1997 there were 1,955 pedestrian-related fatalities recorded, of which 1,041 (53%) occurred on the roadway and 914 (47%) happened offroad. Five industry divisions demonstrated high relative risk indices when compared to the overall risk (Construction RR=4.15; Agriculture/Forestry/Fishing RR=3.80; Transportation/Communication/Public Utilities RR=3.14; Mining RR=2.77; Public Administration RR=1.74). Using 2 analyses, significantly higher rates ($p<.05$) were calculated for roadway versus offroad fatalities within public administration (.44/

100,000 workers vs. .05/100,000), and construction (.85/100,000 vs. .33/100,000). Offroad fatality rates were significantly higher than roadway rates within mining (.60/100,000 vs. .18/100,000) and agriculture, forestry and fishing (.80/100,000 vs. .27/100,000). When comparing roadway to offroad incidents, different vehicle types were identified as predominant injury sources. Cars contributed nearly 36% of roadway deaths, while machinery (20.4%) and industrial/offroad equipment (20.6%) was the primary cause of offroad deaths. Semi-trucks contributed 14% to the offroad fatalities while these vehicles represented over 27% of roadway deaths. The ratio of offroad to roadway fatalities was 3.64 for pickup trucks.

These descriptive epidemiologic results warrant further investigation and provide insight for future research efforts in the area of pedestrian-related occupational fatalities. Additional consideration should be given to the dissimilar worker exposures (roadway vs. offroad) when developing prevention and control strategies within specific industries.

H1.2 The Association of Age and Occupational Motor Vehicle-Related Fatalities—Dellinger AM, Pratt SG

Motor vehicle-related (MVR) injuries are the leading cause of occupational death; approximately 1200 workers are killed each year on-the-job. Crash risk factors vary by age. The distribution of motor vehicle fatality rates by driver age follows a “U”-shaped curve. After adjusting for the amount that they drive, the youngest and oldest drivers have higher death rates than all other age groups. Young drivers have crashes in which risk taking behavior and inexperience play a role. Older drivers’ crashes are more likely to involve failure to yield (i.e., left turns, merging). We explored whether the pattern of occupational MVR deaths was similar to the overall pattern.

Data from the Census of Fatal Occupational Injuries for the years 1992-1997 were used to explore the distribution of MVR occupational fatalities by age. Fatality rates per 100,000 full-time equivalent (FTE) workers are reported. Fatality rates increased monotonically as age increased, from 0.8 per 100,000 FTE for persons 15-17 years of age to 5.9 per 100,000 FTE for persons 75 and older. Rates followed a steady and moderately increasing pattern up to age 64, after age 65 rates increased sharply.

The proportion of deaths was compared to the proportion of FTE workforce by age group. Younger workers were under-represented (dying less frequently than expected) and older workers over-represented (dying more frequently than expected). For example, workers age 18-24 years comprised 11.4% of the FTE workforce and 9.3% of the deaths. Workers age 65-74 years comprised 1.8% of the FTE workforce and 5.4% of the deaths, three times the expected proportion. Only workers age 45-54 years had deaths in proportion to their representation in the workforce (20.5% of FTE workforce,

21.3% of deaths). The distribution of occupational MVR deaths differ from nonoccupational MVR deaths.

H1.3 Occupational Highway Fatalities Involving Semi-Trucks, United States, 1992-1997—Pratt SG, Strotmeyer SJ

Despite recent declines in highway deaths, fatalities involving large trucks (>10,000 lbs. GVW) increased from 4,462 in 1992 to 5,374 in 1998 (+20.4%), according to the Fatality Analysis Reporting System (FARS). The Census of Fatal Occupational Injuries (CFOI) showed that occupational highway deaths involving semi-trucks increased from 375 in 1992 to 551 in 1997 (+46.9%).

CFOI identified 2,914 semi-truck fatalities: operators (2,073); other workers in vehicles that collided with semi-trucks (706); and pedestrian workers struck by semi-trucks (135). Of the operator fatalities, 37.4% were non-collisions, 31.6% collisions, and 24.2% vehicle-vs.-stationary-object events. The truck most often struck: no other object (34.8%); another semi-truck (16.3%); another vehicle (14.9%); or a guardrail or other barrier (8.9%). The transportation industry (TCPU) had the highest frequency and rate of operator fatalities (1525, 2.93/100,000). Fatalities were lowest at 9 p.m. (31), increasing steadily and peaking at 5 a.m. (105).

The 706 other workers killed in semi-truck incidents were driving or riding in cars (32.9%), pickup trucks (25.8%), vans (12.0%), tractors (3.1%), or another vehicle (24.4%); 1.8% were not classified as vehicle occupants. Highest frequencies by industry were in services (127) and TCPU (102); rates were highest in mining (.42) and agriculture/forestry/fishing (.29). Unlike operator fatalities, these events were most frequent between 9 a.m. and 4 p.m.

Of the 135 pedestrian worker fatalities involving semi-trucks, 54.1% occurred in the roadway, the remaining 45.9% on the roadside. Over half worked in construction (37.0%, .11/100,000) or TCPU (24.4%, .06/100,000). Almost two-thirds of pedestrian fatalities occurred between 7 a.m. and 3 p.m.

Prevention strategies for operator fatalities include mandatory seat belt use, adherence to speed limits and hours-of-service regulations, and regular vehicle maintenance and inspection. Others who drive for work, or work on foot near semi-trucks, should receive training addressing truckers’ blind spots, maneuvering capabilities, and braking distances.

H1.4 Traffic Crashes and Productivity Losses: What the Research Shows—Herbel SB

The Network of Employers for Traffic Safety (NETS) is a public/private partnership founded in 1989 to address the human and economic impact of traffic crashes on the nation’s workforce, families and communities.

Three American workers lose their lives in a motor vehicle crash each day, making it the leading cause of workplace death and injury in the U.S. today. Studies conducted by the American Automobile Association, Nationwide Insurance, NETS and the National Institute of for Occupational Safety and Health, estimate that 40 percent of the workforce experiences time off the job due to motor vehicle crashes during any given year. Each incident results in an average of five to six hours of lost work time. In addition, most of the survey respondents reported a degradation in productivity while on the job due to paperwork, phone calls, arranging replacement transportation, inquisitive colleagues, pain, suffering, etc.

To prevent these incidents and mitigate the consequences when they do occur, NETS recommends that employers create a culture that values safe driving behavior. Among the specific actions recommended are the following:

1. Utilize pre-employment screening.
2. Conduct periodic motor vehicle records checks
3. Form a broadly representative safety committee.
4. Develop a comprehensive safety policy and an incident reporting system.
5. Send clear messages from leadership.
6. Form a safety committee.
7. Implement training, education and awareness programs.
8. Incentivize safe driving behavior.
9. Measure results.

NETS helps employers reduce the cost of doing business by providing training, technical assistance, a quarterly newsletter, a web site (www.trafficsafety.org), networking, traffic safety education and awareness materials and special countermeasure campaign materials.

Session: H2.0

Title: Training Intervention Effectiveness Research (TIER)

Category: Special Session

Organized by Greg Loos, National Institute for Occupational Safety and Health

Moderator(s): Greg Loos

H2.1 Overview of the TIER Model—Loos GP

In an effort to identify the elements of training that are critical to increased effectiveness, the Training and Educational Systems Branch (TESB) of EID has developed a research approach that the branch will follow hereafter in its studies, the Training Intervention Effectiveness Research (TIER) Model. The TIER research model is designed to (1) take into account the intrinsic challenges of identifying specific factors that make the training-learning-action continuum successful, (2) logically match research efforts with the nature of the question(s) at hand, (3) minimize training and curriculum development risks, and (4) concentrate research resources.

The TIER Model is a multi-method approach to study the effectiveness of training that utilizes qualitative and quantitative data gathered systematically across four stages of investigation. Stages 1 and 2 are components of formative evaluation in which the objectives and processes of training are conceptualized, drafted, and refined. During these stages, researchers explore instructional alternatives to determine which are most appropriate for study. Stages 3 and 4 are components of summative evaluation—a systematic attempt to determine if the fully developed training intervention is meeting its objectives as planned or desired. As proffered, the TIER Model is applicable to training intervention research across topical domains.

H2.2 Relationship of TIER to Injury Control—Loos GP

Two-in-five of all workplace injuries occur among workers the first year on the job. In FY 99 EID initiated several new worker interventions to help reduce this statistic, these include: (1) incorporating OSH criteria as part of the National Skill Standards Board (NSSB); (2) developing model OSH curricula for secondary vocational education programs; (3) funding three cooperative agreements (in New England and two locations in California) to establish community-based model interventions to increase awareness of OSH-issues related to young workers. Working with NIOSH personnel from across the Institute, EID contributed to the NSSB effort by helping formulate the “Standard for Standards” document; the definition of a “High-Performance Workplace;” and the identification of six Manufacturing Skill Standard Concentrations, Critical Work Functions, Key Activities and their respective Performance Indicators. The NIOSH Electrical Safety Curriculum is being tested for effectiveness in a controlled study at 52 secondary schools nationwide. Receipt of OMB-clearance for a research study of training intervention effectiveness for this project was a first for EID. The study should be completed in FY00.

H2.3 Electrical Safety Training—Fowler T

EID/NIOSH, with extensive input from classroom teachers and the professional community, developed a model curriculum on electrical safety for secondary school vocational education students. In FY 2000, 49 teachers in 7 states agreed to participate in the study and received curriculum materials at the start of the Fall semester. Instruction of the test curriculum was completed by 43 teachers (and approximately 700 students). Pre-, Intermediate, and Post-training data has been collected on student knowledge gain, attitude change, and behavioral intent. In addition, classroom observational, and student focus group, data was collected at 20 sites. A final data set measuring student retention of knowledge, attitude and behavioral intent is scheduled for collection in September 2000. This study will evaluate what components of the curriculum, and order of presentation, produced the best learning outcomes.

H2.4 Future TIER Studies—Merry C

Presently, four other TIER studies are underway: (1) comparing effectiveness of classroom- and Internet-based instruction in the correct use of the NIOSH lifting equation - TIER Stage 3; (2) comparing effectiveness of text- and video-based instruction among different health care workers in proper respirator use to reduce TB exposure - TIER Stage 3; (3) development of instructional computer kiosks for individualized instruction with low-literacy publics - TIER Stage 4, (4) use of graphics to communicate OSH to non-English speaking and illiterate workers - TIER Stage 1, and (5) use of short course delivery mechanisms for OSH training in small businesses - TIER Stage 1. These efforts will be described briefly.

Session: H3.0

Title: Cross-cutting Mining Research for Injury Prevention in Other Industries

Category: Special Session

Organized by Jeffrey Welsh, National Institute for Occupational Safety and Health

Moderator(s): Jeffrey Welsh

H3.2 Safety Issues in Blasting—Rehak TR, Bajpayee TS

Annually, billions of pounds of explosives are used in the United States by the mining and construction industry. Blasting, although hazardous, is considered a very essential component of these operations. Each blast is associated with fragmentation. In many instances, rocks thrown (flyrock) beyond expected bounds result in fatalities or serious injuries. Several of the reported incidents involved innocent bystanders.

Accident reports/information collected from the Mine Safety and Health Administration, other Government agencies, and through Internet searches have been gathered. A detailed trend analysis of blasting injuries in both the mining and construction industry was tabulated. The data demonstrates the severe nature of all blasting incidents.

In addition, factors/parameters such as: insufficient stemming; poor shot design; burden mismatch; improper firing sequence; improper drilling have been studied. This information, along with why there is a lack of blast area security will be presented and discussed in the context of defining likely blasting scenarios.

H3.3 Identifying Fatal and Non-fatal Injuries Attributed to Water Well Drilling Operations—Matetic RJ, Ingram DK

This presentation will demonstrate that OSHA citations/violations and health and safety issues are directly related and effect the water well drilling industry. Suggestions and options will be presented to minimize the hazards that result

in OSHA citations/violations. Ultimately, the information portrayed will save lives and reduce injuries to personnel working in the water well drilling industry.

A comprehension review of the Bureau of Labor Statistics (BLS), indicate that water well drillers are achieving higher incidence rates, of some non-fatality injuries, than any other industry. The BLS data also displays the water well drilling industry has averaged 10 fatalities per year from 1990 - 1997. These injuries and fatalities could be considered alarming when you realize the construction industry, in which water well drilling is classified under, represents only 5% of the total labor force in America. Discussions on the source and events that lead to the fatalities and non-fatal injuries of the water well drilling industry for a four year period will be covered. The discussion will further display on-site examples of potential hazards that result in fatalities and non-fatal injuries that drillers/operators face everyday. Overall, many operators/drillers are experiencing similar situations and there are inexpensive steps that can be taken to reduce these costly accidents.

Information on OSHA citations/violations for a three year period will demonstrate that drillers/operators can avoid, eliminate, or minimize citations/violations. The top five violations and cost of those violations will illustrate the impact OSHA has on the water well drilling industry. Explanations as to why these citations/violations are major issues and options to improve worker safety and avoid, eliminate, or minimize these citations/violations will be addressed.

H3.4 Protecting Workers From Electrocutation Caused by Contact of Cranes, Haul Trucks and Drill Rigs With Overhead Power Lines: A New Approach—Cawley JC, Homce GT, Sacks HK, Yenchek MR

Overhead electric power lines present a serious electrocution hazard to crane, truck, and drill rig operators in the mining industry. Typically constructed using uninsulated conductors supported on towers or poles, overhead power lines are the most common means of overland electric power transmission and distribution. Frames of equipment in contact with energized overhead lines become elevated to a high voltage. Contact by workers from the "hot" frame to ground can cause serious injury in the form of electrical shock, burns or death.

Between 1980 and 1997 at least 94 mobile equipment overhead line contact incidents were reported in the U.S. mining industry, with 114 injuries, 33% of them fatal. Most incidents involved cranes (47%), dump-bed trucks (24%), and drills (14%). In addition, an estimated 2300 overhead line contact accidents (total in all industries) occur each year in the U.S. An examination of accidents in the mining industry indicated that more than one-half of recent fatalities occurred when operators attempted to dismount vehicles in contact with overhead power lines or when nearby workers contacted the

energized vehicle frame. The authors contend that widespread use of a simple device that alarms when a vehicle frame becomes energized could have prevented many of these fatalities.

This presentation describes the results to date of a project to measure voltage differences and currents flowing on the vehicle frame as a result of accidental overhead line contact in cranes and dump-bed trucks. A practical, low-cost concept to detect the contact of mobile equipment with high voltage lines and warn those nearby is presented.

H3.5 Development of the Hazard Recognition Training Module for Construction, Maintenance, and Repair Work Activities—Barrett EA, Rethi LL

Recent studies have concluded that 39 to 65 percent of all injuries to miners occur when they perform construction, maintenance, and repair type work activities in the conduct of their jobs. The number of injuries is particularly high at surface aggregate operations; however, the problem exists for all locations and commodities. To address this issue, an interactive, 3-D slides training module was developed for teaching such workers to recognize hazards in the workplace. Twelve groups of miners, a total of 339 persons, from mining operations throughout the United States were trained using the exercise. The subjects were tested before and after the training intervention to determine if the objective of the instruction was achieved. Test results indicated that over 70 percent of them showed improvement in their test scores. Following the posttest, subjects completed a seven-item Likert-scale, self-reporting measure consisting of questions relating to exercise validity and utility of the training program. More than 93 percent of the miners indicated that they learned something new from the training exercise and they would use this information to work more safely.

Session: H4.0

Title: Traumatic Injury Studies

Category: Injury Surveillance

Moderator(s): Letitia Davis

H4.1 National Estimates of Traumatic Occupational Injury in the United States—Warner M, Fingerhut LA, Barnes P

Introduction: The National Health Interview Survey (NHIS) has been used to make national estimates of non-fatal occupational injury in the United States since its inception in 1957. The NHIS questionnaire was extensively redesigned in 1997 including changes to: 1) probe question and inclusion criteria for injuries; 2) recall period; 3) severity threshold; and 4) phrasing and placement of the questions. Methods for identifying occupational injuries and the working population from the NHIS are presented.

Methods: Data from the US civilian non-institutionalized population were collected using Computer Assisted Personal Interview (CAPI) from an adult member of the sample household about all medically attended injuries occurring in the previous three-month period to any member of the family. Occupational injuries were identified by selecting the categories 'paid work', 'unpaid work', and 'working around the house or yard' from the responses to the question about what the person was doing at the time of the injury. Edited verbatim responses to the questions of how the injury occurred were also reviewed. Traumatic occupational injury episode data are presented by demographics, external cause, diagnosis, and circumstances surrounding the episode.

Results: In the United States in 1997, there were an estimated 6.27 million traumatic injury episodes requiring medical attention occurring while persons were engaged in paid work. A further .96 million episodes occurred while persons were engaged in unpaid work and 3.36 while persons were working around their house or yard.

Discussion: The redesigned NHIS is a useful source of information about medically attended non fatal traumatic occupational injuries in the United States because occupational injury experiences are reported without regard to compensation. The NHIS also includes information about injuries occurring in non traditional workplaces. The strengths and limitations of the NHIS redesign and methods for identifying occupational injuries and the working population are discussed.

H4.2 Surveillance for Nonfatal Occupational Injuries and Illnesses Treated in Hospital Emergency Departments—United States, 1998—Jackson LL

The National Electronic Injury Surveillance System (NEISS) is used by the National Institute for Occupational Safety and Health for surveillance of nonfatal occupational injuries treated in U.S. hospital emergency departments (EDs). In 1998, NEISS captured work-related injuries and illnesses treated in a 67 hospital ED sample based on a national stratified probability sample of all U. S. hospitals with a 24-hr emergency department and a minimum of six hospital beds. We made national injury/illness estimates based on statistical weighting for each NEISS case in the sample. We determined injury/illness rate estimates by using 12-month averages for full-time employees (FTE = 2,000 hrs/yr) from the 1998 Bureau of Labor Statistics Current Population Survey.

An estimated 3.6 million occupational injuries and illnesses were treated nationally in EDs. The occupational injury/illness rate for 1998 was 2.8 per 100 FTE. The injury/illness rate for men (3.4 per 100 FTE) was almost twice the rate for women (1.8 per 100 FTE). The rate was highest for the younger-aged workers with the injury/illness rate decreasing with worker age.

In 1998, hands and fingers were the most commonly injured part of the body (30%). Hand and finger injuries were treated almost twice as frequently in EDs as other anatomic groups: trunk/back/groin (18%), head/face/neck (17%), arm/wrist/shoulder (15%), and leg/knee/ankle/foot (17%). Seventy percent of the injuries involved lacerations/punctures (26%), sprain/strain (25%), and contusion/abrasion/hematoma (19%).

The magnitude and rate of ED-treated injuries/illnesses, as well as the general injury/illness patterns for 1998 were similar to those reported for 1996 from NEISS. These data are one of several yardsticks that will be used to assess a reduction in work-related injuries and illnesses as targeted by Healthy People 2010 and the National Occupational Research Agenda.

H4.3 Exposing U.S. Disabling Morbidity - The BLS Data Revisited—Courtney TK, Webster BS

The United States Bureau of Labor Statistics' (BLS) annual survey of occupational injuries and illnesses (ASOII) is one of the most frequently utilized sources of data on national occupational morbidity. In 1992 the BLS introduced a new and expanded survey method that collects more detailed data on cases with days-away-from-work (DAW). While the method provides detail on the body part, nature, extent and certain antecedents of these cases, the published data are most often presented univariately. This makes it difficult to assess the extent of many common injuries. Expanded access to the ASOII data is now available on the world-wide web. However, comprehensive data which connect exposure and event (EE) type with clearly defined injury and illness outcomes (BP-NOI) have not been available thus far.

To improve understanding of national DAW case outcomes and their related exposures, the present study utilized a special data call and reduction strategy to identify the leading BP-NOI-EE combinations for DAW cases by frequency and severity (median DAW) for 1996. Overexertion, bodily reaction, falls on the same level and struck by object were among the most common events associated with disabling injuries in 1996. The presentation will examine each of these EE groups and several others in greater detail to determine the specific nature and location of the disabling injuries attributed to each.

H4.4 Safety Impacts of Peer-to-Peer Workplace Substance Abuse Prevention—Miller TR, Spicer RS, Becker LR, Nelkin VS, Sogie-Thomas B

Since the late 1980s, a major transportation company has used a 3-pronged approach to reduce drinking and drugging in the workplace. First, they offer both Employee Assistance Program (EAP) services and referral-free access to treatment services. Second, they drug-test pre-employment, for cause, and randomly (with alcohol included in the tests since 1994). Third, union contracts have established a peer prevention

and early intervention program, PeerCare, run by the unions. This program has trained more than one third of the workforce to recognize when someone is high and get them off the worksite. Employees on drugs or alcohol also can be excused from work without penalty. Upon return to work, the employee is confronted by a peer trained to assess whether the incident is indicative of a substance abuse problem and steer employees with problems to help.

A time series analysis is examining program impacts on injuries, disciplinary actions, and absenteeism, as well as on random drug test results. The analysis of injury rates uses other firms in the industry as a control group which implemented random testing without PeerCare.

Preliminary findings are that the PeerCare program, in conjunction with random drug testing, reduced injuries significantly and substantially more than random testing alone. The injury rate dropped significantly as the percentage of employees trained in PeerCare rose. Random alcohol testing had no incremental impact, but may have impacted injury rates at firms without PeerCare. The cost savings from PeerCare exceed its costs. This evaluation clearly demonstrates that substance abuse prevention at work is a cost-effective way to dramatically improve worker safety.

H4.5 Mortality Patterns at a Large U.S. Manufacturing Company From 1974 Through 1998—Reeve GR

A review of 104 occupational fatalities over a 25-year period among employees of a large manufacturing company was conducted. Established nationally recognized coding systems were used to initially describe this case series. Additional reviews of the case series was conducted to provide closer linkage to the company's existing injury prevention processes. These additional reviews resulted in the cases being classified into one of four major categories: 1) Work Practices and Processes; 2) Motorized Vehicles; 3) Issues Relating to Plant Environment and Equipment Design; and, 4) Violence in the Workplace. Half of the fatalities (n=51) involved Work Practices and Processes. In situations where workers were functioning within the general limits of acceptable work practices, the process of moving large dies or other metal stamping equipment was associated with the highest number of fatalities. Failure to lock-out or de-energize equipment during repair operations accounted for 18 fatalities. The next largest category, Motorized Vehicles, accounted for nearly 30% (n=28) of the fatalities with only 10 of them occurring inside company buildings. The other 18 occurred outside of a plant environment and involved the largest percentage of salaried employees. In the major category of Environmental or Equipment Design, nine deaths involved plant environmental hazards, such as lack of barriers to protect workers from falls or drowning, or lethal exposures to poisonous gases. A very small number of deaths (n=4) involved line workers operating equipment at their work

stations when the equipment failed and fatally injured them. Five fatalities were due to violence in the workplace. This case review was used as an integral part of framing the company's recently Safety Leadership Initiative.

H4.6 Traumatic Work-Related Fatal Injury Amongst Maori of New Zealand 1985-1994—McCracken SB, Feyer A-M, Langley JD, Broughton J

Maori are the indigenous people of New Zealand, and represent 15% of the country's population. Despite the implicit assurances of equal health status contained within the nation's founding document, the Treaty of Waitangi, Maori are disadvantaged in almost every measure of health. Because of flawed identification processes, both in numerator and denominator data, little progress has been made in understanding the true extent, nature and distribution of work-related fatal injury among Maori. The present study aimed to more accurately describe the problem, identifying specific circumstances associated with Maori deaths that will assist in developing preventive strategies for Maori.

Coronial files with an ICD 9-CM E-Code between E800 and E989 and a decedent aged 15-84, were reviewed as part of the study of all New Zealand work-related fatal injuries occurring between 1985 and 1994. Basic descriptive and causal information concerning each incident were abstracted and coded. Maori were identified within this dataset by either the classification recorded upon death certificates or if they were identified as Maori within the Coroners files.

In all, 91 Maori deaths were identified within the 817 work-related fatalities. Notably, agreement between the data sources used to identify ethnic status was only around two-thirds. Crude rates were significantly higher for Maori and did not show the significant linear decline across years, compared with the non-Maori rates. Rates adjusted for employment patterns based on ethnicity did not differ.

This study is one of the first attempts at investigating work-related injury for an indigenous population. New Zealand is unusual in that a treaty exists which includes obligations regarding equity in health status for its indigenous population. The present study confirms that inequities exist. Moreover, the study underscores the need for better data if these inequities are to be properly addressed.

Session: H5.0

Title: International Comparison

Category: Other Topics

Moderator(s): Gordon Smith

H5.1 A Comparison of Work-Related Fatal Injuries to Agricultural Workers in Australia, New Zealand and the United States—Horsburgh S, Marsh S, Feyer A-M, Langley J, Stout N, Williamson A, Driscoll T

Recent studies of work-related fatal injuries in Australia, New Zealand and the United States have shown agricultural workers to be at considerably higher risk than the national average. What is striking when the figures from these studies are compared is that while the rate of fatal injury has decreased substantially in recent years for these workers in the United States, there has not been any sustained decline in New Zealand or Australia.

The objective of the current study is to examine work-related fatal injuries in agricultural workers from these three countries to uncover possible explanations for the apparent differences in performance. Data has been collected from Australia and the United States for the period 1989-1992 and, to overcome low numbers, for 1985-1994 in New Zealand. Data were obtained from coronial records for Australia and New Zealand and extracted from the National Traumatic Occupational Fatalities surveillance system in the United States. Considerable effort has already been expended to harmonise the data from the three countries so that valid comparisons can be made. This includes applying a standard case definition and creating comparable groupings for occupation, industry and other incident variables. Where applicable, these have been applied to both numerator and denominator data so that rate comparisons can be performed.

At the current time the harmonisation of the datasets is nearing completion. Detailed analyses comparing incident variables, including mechanism, cause of death and agency, will be completed. It is hoped that the investigation of similarities and differences between agricultural workers in the three countries will generate hypotheses to explain the differences in their rates of fatal injury and, in doing so, provide direction for future injury control strategies.

H5.2 Comparing the Causes of Work-Related Fatal Injuries in Australia, New Zealand and the United States Using Narrative Information—Williamson A, Feyer A-M, Stout N, Driscoll T

Narrative or text-file information is often collected to supplement injury data in large-scale datasets. Often, however, this style of information is not analysed because of uncertainty about the quality of the analysis. The opportunity arose in this project to investigate systematically the effects of coding of the circumstances of fatal occupational injury using

narrative analysis compared to analysis using standard methods. This project was part of the three country collaborative study of occupational fatalities, which compared population data from New Zealand, Australia, and the USA. In these datasets, both Australia and New Zealand used the same standard code for mechanism of injury, but the USA did not, yet all countries included narrative information on the circumstances of the injury in their datasets. It was possible, therefore, to develop a narrative-based text search using the existing mechanism coding for Australia and New Zealand which was maximally accurate in reflecting the already-coded mechanism information. It was then possible to apply the narrative search to the US data as well, in order to compare the circumstances of injury in each of the three countries. The results showed that narrative-based coding produced the same patterns as the standard coding. Hit by moving objects and falls were the most common mechanisms of injury for each country. Some types of mechanisms, however, could be represented more accurately than others. The main errors in the narrative analysis were lack of sensitivity in picking up cases rather than poor specificity of coding.

H5.4 Older Workers: A Comparison of Work-related Fatal Injuries in Australia, New Zealand, and the US— Marsh SM, Horsburgh S, Usher H

A recent study comparing work-related fatality data from Australia, New Zealand and the US indicated that workers over 55 years of age in all three countries had higher fatality rates than workers 16-54. The objective of the current study is to compare data from these three countries in more detail for workers 55 and older to identify the specific agents leading to the high fatality rates. For this study, data from the US (the National Traumatic Occupational Fatalities surveillance system) and Australia (Coroners' records) were included for 1989-1992. Because of the small number of cases, data for a longer time frame (1985-1994) was included for New Zealand (Coroners' records). Cases were included if they involved a decedent who was fatally injured while at work, where death resulted from an unintentional cause or homicide. Work-related injuries on the road involving traffic or work-related injuries to bystanders were excluded. To permit for more comparable groupings, occupation and industry classifications were substantially customized. To allow for rate comparisons, equivalent modifications were applied to both numerator and denominator data. While specific results for this comparison have not been organized, the initial comparison indicated that as age increased, the rate per 100,000 workers increased for all three countries. In general, when comparing rates by age for workers 55 and older, rates per 100,000 workers were highest in Australia and lowest in the US. More detailed comparisons for workers 55 and older will be provided by industry, occupation, cause of death, and specific mechanism of death. Similarities and differences from these comparisons will be highlighted. Examining similarities in the circumstances of fatal injuries may help identify hazards

common to all three countries, while differences in the circumstances of fatal injuries may allow for the identification of possible directions for prevention.

H5.5 Occupational Injury Mortality Rates: Comparison of New Zealand, Australia and the United States— Feyer AM, Williamson A, Stout N, Driscoll T

A major impediment to international comparisons of the nature, distribution and causes of work-related fatal injuries has been the lack of comparability between data sets, both in terms of inclusions in aggregated statistics, and also in terms of classifications used to group the data on critically important dimensions such as occupation of the injured workers. The present study aimed to compare work-related injury deaths in New Zealand, Australia and the US, using national collections based on vital records covering the decade 1985 - 1994. Fatal injuries of persons aged 16 to 84 years, where death resulted due to unintentional causes or due to homicide were included, while work-related motor vehicle traffic crashes and work-related injuries to bystanders were excluded. Classifications of occupation and industry were harmonised to produce comparable groupings in both numerator and denominator data.

The rate of fatal injury declined in each country over the study period, but was consistently highest for New Zealand and lowest for the US. The distribution of age specific rates was remarkably consistent, with a very marked increase in rate after 60 years of age in each country. The distributions by occupation and industry were also remarkably consistent, with the highest rates evident among Agricultural workers (including farming, forestry and fishing) and in the category covering trade workers, machine operators and labourers.

The relative ranking of the three countries in this comparison differs to that based on data published through routinely collected data such as that published by the ILO, highlighting the importance of comparability of data sets. The similarity of the distributions of deaths by age, occupation and industry suggest that some of the risk factors for work-related injury deaths will be common to all three countries, at least as far as indicated by analysis of broad groupings for industry and occupation.

Session: H6.0

Title: State Experience

Category: Other Topics

Moderator(s): James C. Helmkamp

H6.1 The Epidemiology of Serious Occupational Burn Injuries in Alabama— Taylor AJ, McGwin G, Smith DR, Birmingham BR, Rue LW

Introduction: Patterns of occupational burn injury vary by geographic region; however, there are no studies in the

published literature of patterns of occupational burn injury in the Southeastern United States. The purpose of this study is to describe the epidemiology of serious occupational burn injuries treated at an American College of Surgeons verified Burn Center.

Methods: Patients admitted to University of Alabama at Birmingham (UAB) University Hospital Burn Center between November 17, 1994 and December 31, 1999 for occupational burn injuries treated were included in the study. Demographic factors, type and severity of burns, occupation, and other factors were abstracted from medical records.

Results: Of 345 occupational burns (24.0% of total burns) treated, the majority occurred among males (96.5%, n=333) and those of white race (76.2%, n=263). The mean age was 37.5.

The most common burns resulted from flame, followed by electrical burns, and scalds. The most heavily represented occupations were “manufacturing” (19.1%, n=66), “electrician” (16.2%, n=56), and “laborer” (16.2%, n=56). Occupation was not documented for 13.0% (n=45) of patients. All manufacturing employees, 62.5% (n=35) of electricians, and 76.8% (n=43) of laborers were injured in an industrial setting, as were 68.7% of the total (n=237). Electricians sustained electrical (69.6%) and flame (26.8%) burns. Manufacturing employees and laborers sustained mainly flame and chemical burns, roofers scald burns, cooks scald burns and burns due to explosions, and mechanics flame burns.

Patients sustaining burns due to explosions and flames were more seriously injured than patients sustaining chemical, electrical, scald or contact burns. The mean length of ICU stay and hospital stay were 0.9 days (0 minimum, 60 maximum) and 13.7 days (1 minimum, 134 maximum), respectively. Sixteen patients (4.6%) died.

Conclusions: A significant number of burn injuries occur in the workplace. An understanding of their epidemiology is crucial to prevention efforts.

H6.2 Epidemiology of Work-related Burn Injuries: Experience of a State Managed Workers Compensation System—Islam SS, Nambiar AM, Doyle EJ, Velilla AM, Biswas RS, Ducatman AM

Population-based incidence rates of work-related burn injuries and associated risk factors specific to anatomic sites and degree of burn are not known. Using a state managed Workers Compensation database, we estimated incidence rates of work-related burn injuries and identified high-risk occupations and associated exposures. The annual incidence rate of occupational burn was 26.4 per 10,000 workers with the highest rate observed in the manufacturing sector for

males and service sector for females. Welders, cooks, laborers, food service workers, and mechanics had higher incidence rates of burn injury compared to other occupations. Wrist and hand burns accounted for a majority of burn injuries, with females experiencing greater incidence of these distal upper extremity burns (8.9 in females and 6.7 in males per 10,000 workers respectively). Third degree burns (incidence rate 1.3 per 10,000 workers) were also most frequently observed in the upper extremities compared to other anatomic sites. The majority of wrist and hand burns were caused by hot liquids/objects while the majority of eye burns were associated with chemical exposures. Younger cooks and food service workers were at greater risk of burn than older co-workers. Specific occupations are associated with degree of burn, anatomic site, and cause of injury. This information will be useful for targeted intervention among high-risk occupations and work groups.

H6.3 Incidence and Risk of Work-related Fracture Injuries: Experience of a State Managed Workers Compensation System—Islam SS, Biswas RS, Nambiar AM, Syamlal G, Velilla AM, Doyle EJ, Ducatman AM

Population based incidence of work-related fractures and associated risk factors have not been well documented. Using a state managed workers compensation database, we have identified 3,454 work-related fractures that occurred between July 1, 1994 and June 30, 1995. Incidence rate of fracture was highest in the agricultural sector (194.5 per 10,000 workers), followed by mining (168.8 per 10,000 workers), construction (111.7 per 10,000 workers) and manufacturing (87.5 per 10,000 workers). In each industrial sector, males had significantly higher incidence rate than females except for the educational sector. Fracture of the phalanges was the most common fracture across all industrial sectors (15.8 per 10,000 workers), followed by foot bones (9.5 per 10,000 workers), and carpal bones (7.9 per 10,000 workers). The incidence rates of fractures varied by anatomic sites and occupations with laborers, truck drivers, electricians, carpenters, and nurse aides having higher rates of specific fractures than other occupations. The most common cause of fractures varied by anatomic sites with fall to same level or different level being the most common cause for all anatomic sites except face bones, phalanges, and carpal bones. Similarly, the exposures and surfaces associated with fractures varied by anatomic sites with femur, patella, radius and ulna fractures occurring in association with indoor surfaces. Majority of the ankle fractures occurred in association with outdoor surfaces. This study showed that specific occupations and anatomic sites are associated with specific causes and exposures. This information will be useful in the development of a targeted prevention intervention.

H6.4 Work-Related Traumatic Head and Brain Injuries in Washington State, 1990-1997—Cohen MA, Kalat J, Silverstein B

Traumatic head and brain injuries (THBIs) are severe, life-threatening injuries. Their impact on the worker, the worker's family, the employer, and society can be great. To prevent future injuries from occurring, we must better understand the nature of these incidents, the situations in which they are occurring, trends over time, and their costs.

Accepted Workers' Compensation claims for hospitalized traumatic head and brain injuries in the Washington State Fund system were analyzed. The occurrence of injuries and costs were described by occupation, industry and Washington Industrial Classification (WIC) codes. Various trends were also investigated over time.

Workers with the highest risk of having a traumatic head or brain injury worked in logging, roofing, and road construction. On average, the total workers' compensation claim cost was

\$135,000/claim, the injured workers took nearly 400 days off work, and spent 67 days in the hospital. The annual workers' compensation cost of these injuries is approximately \$14 million. On average, there were 106 THBIs per year in this time period, which amounts to 9 THBIs per 100,000 workers each year in Washington State.

Traumatic head and brain injuries tend to occur in situations where work is being conducted on elevated surfaces, around/in vehicles moving at high speeds and in proximity to large objects elevated above the worker. In most cases, there are known methods to reduce the exposures or the energy involved in the incident. These methods include conducting work at ground level, reducing vehicle speeds, and increasing the distance between the worker and the hazard. Personal protective equipment can also be used (e.g. fall protection systems, seat belts, and hard hats). Like most workplace injuries, traumatic head and brain injuries are preventable. Work sites and conditions should be assessed for their potential to cause injury and hazards eliminated before an injury occurs.

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