

planting. Bulk soil samples were collected from the fields where dust samples were collected. Dust samples generated by the system from bulk soil samples had elemental and mineralogical characteristics similar to the respective field dusts. The results suggest that the new dust generation system can provide valuable information about soil dust characteristics and can be used as a stable dust source for other studies, such as animal toxicity tests.

3. COST OF AGRICULTURAL INJURIES AND OCCUPATIONAL DISEASES IN FINLAND. R. Rautiainen, C. Zwerling, K. Donham, L. Burmeister, N. Sprince, University of Iowa, Iowa City, IA; S. Reynolds, Colorado State University, Fort Collins, CO; E. Eskola, P. Saarimäki, Farmers' Social Insurance Institution, Espoo, Finland

Background. Agriculture is a hazardous occupation, however, little cost information exists and interventions are often planned in the absence of cost data. This study was designed to provide cost information for targeting research and intervention. The study used 1996 claims data ($n=10,992$) from the Finnish farmers workers compensation, which covers all farmers ($n=132,118$) and provides various types of compensation.

Objectives. The objectives were to characterize injury and occupational disease claim costs, identify costly claim types, and quantify risk factors associated with costs.

Methods. One-way ANOVA was used to identify characteristics associated with high claim costs. General Linear Models procedure was used to measure the effect of risk factors while adjusting for other risk factors. Outcome variables included total cost, medical cost, lost time compensation, permanent disability pension, and rehabilitation. Risk factor variables included age, sex, income, type of work, cause, type of incident, and type of injury.

Results. The total insurance costs in 1996 were 23.5 million EUR and consisted of medical (16%), lost time (37%), accident pension (23%), survivors' pension (3%), inconvenience allowance (7%), rehabilitation (6%) and other costs (9%). The mean injury cost was 1,099 EUR and the mean occupational disease cost was 4,380 EUR. The most costly types of injury/illness included asthma, hypersensitivity pneumonitis, brain and spinal cord injury, amputation, skin disorder, and bone fracture. Transportation, commuting, livestock, horses, and forestry work caused costly claims. Multivariable analysis showed that age, personal cumulative claim rate, income, work activity, type of incident, and type of injury had a significant effect on total cost. Sex, worker status, and injury month had no effect.

Conclusions. From the cost standpoint, prevention priorities include large animals, organic dusts, floors and walkways, slippery and uneven terrain, sudden movements, scaffoldings, ladders, stairs, wagons, circular saws, tractors, and repetitive motion.

4. A SURVEY OF NORTH CAROLINA FARMERS: PERCEPTIONS OF WORKPLACE SAFETY HAZARDS. R. Luginbuhl, North Carolina Department of Labor, Raleigh, NC; V. Jones, Johns Hopkins University, Baltimore, MD; R. Langley, Department of Health and Natural Resources, Raleigh, NC

In North Carolina, the agricultural industry accounts for approximately 30% of the State's revenues and employs approximately 29% of the State's workforce. From 1990 to 1999, the state's population increased by more than 15% annually. In certain areas of the state, where agriculture plays an important role, the non-farming population growth has been higher than 15%. This growth in population has occurred as the farming community has declined statewide. The rapid increase in population has led to a number of problems in both urban and rural areas of the State. At a meeting with the North Carolina Department of Labor's Agricultural Safety and Health staff, a group of North Carolina farmers stated that their most serious workplace safety hazard was driving their farm vehicles on rural roadways. Because the rural traffic profile changes as North Carolina farmland shrinks, and suburban housing grows where crops were once planted, roads now carry more traffic at increased rates of speed. And although only 46 percent of North Carolina crashes occur on rural roads, the traffic fatalities in rural areas are four times greater than traffic fatalities in urban areas. Factors in rural road crashes include: aggressive driving/speeding, the number 1 violation; alcohol, cited in 57% of all crashes; and engineering factors, such as narrow 2-lane roads, and smaller shoulders. A survey written by the North Carolina Department of Labor, Agricultural Safety & Health, and produced and posted by the North Carolina State University Center for Urban Affairs and Community Service, was sent to 1,357 farmers throughout the State. A grant awarded by the Governor's Highway Safety Council funded the project. The survey addressed specific problems and sought solutions from the respondents. The survey also had questions pertaining to the steps the respondent took to ensure safety while driving farm equipment on rural roadways.

5. VIBRATION AND NOISE EXPOSURE AND HEALTH EFFECTS IN LOGGING OPERATIONS. R. Neitzel, M. Yost, K. Zoh, S. Somers, University of Washington, Seattle, WA

Fifty-eight workers from 9 logging companies in Washington, Alaska, and Idaho were assessed for noise and vibration (hand-arm and whole-body) over 6 weeks. Various operations were evaluated, including manual and mechanized falling, harvesting and forwarding, skidding, yarding and landing, processing, log transport, and log sorting/decking. Seventeen types of equipment were evaluated for noise and vibration. In addition to participating in noise

dosimetry and vibration measurements, workers completed activity cards documenting the timing and frequencies of tasks performed and equipment used, and also answered several questionnaires regarding their health status and current and historical occupational and recreational exposures to noise and vibration.

Questionnaire and measurement data were collected using Personal Digital Assistants (PDAs). The results of these questionnaires were compared to those from 2 control groups: one (silviculturists) for hand-arm vibration, and another (office workers) for whole-body vibration.

The exposure assessment results indicate that logging workers are routinely exposed to levels of noise and vibration exceeding the OSHA and NIOSH noise standards and the ACGIH and CEC recommendations for hand-arm and whole-body vibration, respectively. The mean TWA level was 90.2 ± 7.9 dBA (NIOSH) and 85.5 ± 8.9 dBA (OSHA); 77% of all NIOSH TWAs exceeded the 85 dBA NIOSH REL, and 27% of OSHA samples exceeded the 90 dBA OSHA PEL. The majority of hand-arm vibration measurements exceeded the ACGIH recommendation of 4 m/s^2 for 8-hour shifts, and many whole-body measurements exceeded the CEC 8-hour recommendation of 1.15 m/s^2 . Logging workers were more likely to report vibration-related health effects and work-related hearing loss than were the controls. These research findings suggest that loggers are frequently overexposed to occupational noise and vibration, and that these overexposures result in adverse health effects. The research strategy employed allows for identification of risk factors for overexposure; these risk factors can provide guidance for the development of exposure controls.

6. PESTICIDE USE AND PRACTICE AMONG 25 FARMS ENROLLED IN THE IOWA FARM FAMILY PESTICIDE EXPOSURE STUDY. B. Curwin, W. Sanderson, NIOSH, Cincinnati, OH; S. Reynolds, Colorado State University, Fort Collins, CO; M. Alavanja, NCI, Bethesda, MD

Twenty-five farms were enrolled in a recent study investigating pesticide contamination inside the homes. The target pesticides being investigated were atrazine, metolachlor, acetochlor, alachlor, 2,4-D, glyphosate and chlorpyrifos. Personal and environmental exposure samples were collected from each home on two occasions, one shortly after pesticides were applied and the other 2 months later. In addition, a questionnaire was administered to the farmers to determine the pesticides used and the practices involved in pesticide application. Of the 7 target pesticides, atrazine was applied most often. Twenty of the farmers (80%) had applied atrazine to their crops. Glyphosate (64%) and 2,4-D (56%) were the next most common target pesticides, followed by metolachlor (28%), acetochlor (20%) and chlorpyrifos (12%). Alachlor was not used by

any of the farmers. In addition, 25 other active ingredients were used by 20 farmers. Seventeen farmers (68%) applied pesticides themselves with 10 of them using a closed cab, while 14 (56%) had pesticides custom applied. This includes farms where both the farmer and a custom applicator applied pesticides. Every farm except one applied more than one pesticide. The average number of pesticides applied was 4 (range 1-9) with most farms (6) applying 3. Corn was grown by 23 farmers and soybean was grown by 12 (10 grew both soybean and corn). The average crop size was 308 acres (range 16 - 750) for corn and 221 acres (range 2 - 450) for soybean. An average of 125 acres of crop was sprayed. Spraying averaged 4 hours each day on an average 2.5 days. Six farmers wore no PPE at all during spraying activities, while 13 wore gloves, 16 wore long pants, 7 wore long-sleeved shirts, 3 wore rubber boots, 2 wore goggles and 1 wore chemical resistant PPE (e.g., nitrile apron).

PF 102. Occupational Ergonomics: Training and Risk Assessment

Papers 7-12

7. ERGONOMIC TRAINING ANALYSIS. S. Chervak, U.S. Army CHPPM, Aberdeen Proving Ground, MD

A large organization conducted a study to evaluate the effectiveness of various types of ergonomic training with respect to increased ergonomic knowledge and reduced reports of physiological disorders. The study consisted of 840 subjects at 48 different locations. Participation in the study was voluntary. The subjects were divided into six groups based on the type of ergonomic training to be received: (1) no training (the control group), (2) training via self-instructional reading material, (3) video training, (4) one-on-one training, (5) train-the-trainer training, and (6) group training. Subjects completed a questionnaire before the training, two weeks after training, and five months after the training. The questionnaire contained inquired about the subject's general office ergonomic knowledge, body part discomfort and workstation arrangement.

Regardless of the training the subjects received, their knowledge of ergonomics increased immediately after the training and remained significant at the follow-up 5 months later. Initially, subjects who received the one-on-one training had a dramatic increase in their knowledge of ergonomics when compared to the other groups. After the trainer left, however, there was no follow-up, and the employees' knowledge soon decreased. Those who had the opportunity to reinforce their training (i.e., self-instructional reading material) retained their knowledge at the 5-month follow-up interval.

Those employees who received the more personal or involved training (one-on-one and train-the-trainer) had the opportunity to make changes to their workstations, thus showing a significant increase in the number of ergonomic alterations made when compared to the other groups. Also, the train-the-trainer group was the most successful in terms of reducing the degree of body part discomfort.

8. EVALUATION OF ERGONOMIC STRESS IN A MAQUILADORA FACTORY. J. Blas, H. Gomez, University of California, Los Angeles, CA; W. Liu, California State University, Northridge, Northridge, CA

The paper describes the results of an assessment of the ergonomic stress experienced by workers in a Maquiladora factory manufacturing heat sinks for computer components. The assessment focused on the washing and tapping operations in the factory. The workforce consisted of 47% males and 53% females. Job tenure ranged from 2 months to 42 months. The annual turnover rates were 33% and 40% for the washing and tapping operations, respectively. Age of the workers ranged from 17 years to 57 years. Stature of the workers ranged from 143 cm to 172 cm. Workers in the tapping operation were required to handle more than 14,000 pieces per day, while workers in the washing operation were required to carry and push heavy baskets. The results of the assessment indicate that the design of most of the workstation does not match anthropometric characteristics of the Maquiladora workers. This mismatch may result in a higher risk for the development of musculoskeletal disorders/discomfort. A simplified survey was also conducted at the factory. The results of the survey indicate that though workers did complain of muscular fatigue and even neck and back pain, these workers perceived fatigue and pain as a normal component of the job. This study indicates the imminent need for ergonomic training for both production engineers and workers in the Maquiladora industry.

9. THE EFFECTS OF VISUAL CUES, FATIGUE AND TASK PERFORMANCE ON POSTURAL STABILITY WHILE WORKING ON INCLINED SURFACES.

M. Lu, A. Bhattacharya, P. Succop, University of Cincinnati, Cincinnati, OH

Fall-related fatal and non-fatal injuries remain a major safety problem in the workplace. Improper visual cues, fatigue and task performance have been known as major risk factors for falls on a level surface. The effects of the aforementioned risk factors on workers' safety while working on inclined surfaces are not clear. This study investigated the effects of visual cues, muscular fatigue of the lower limbs and reach task on workers' postural stability on three different inclinations—0°, 14° and 26°. Nineteen subjects from roofing-related industries participated in the study. Postural

stability was measured in terms of sway length and area by a force platform. Additionally, a questionnaire was administered to acquire workers' subjective perceived sense of sway and postural instability (PSPSI) for each test condition. The test conditions included 3 inclinations \times 2 visual cues settings (with or without) \times 3 levels of fatigue (full, half and no) \times 2 tasks (forward reach and stationary). Results from a repeated measure analysis of covariance showed that inclination, reach task and their interaction were found to have significant effects ($p < 0.001$) on sway length and area, whereas visual cues were significant on sway length ($p < 0.001$). Both workers' PSPSI and sway were significantly affected by inclination ($p < 0.001$). A correlation analysis showed that the workers' PSPSI was not found to be significantly related to both sway variables. Visual cues and reach task significantly decreased and increased the workers' postural instability, respectively. These effects, however, were not perceived by the workers. On the contrary, fatigue caused the workers' PSPSI to increase significantly, which however, was not found to be a significant factor affecting their postural stability. These mismatches between the workers' subjective PSPSI and objective sway variables imply that training for proper perception of postural control while working on inclined surfaces is needed for fall prevention.

10. TELE-ERGONOMICS: A FEASIBILITY STUDY. J. Pentikis, M. Lopez, U.S. Army CHPPM, Aberdeen Proving Ground, MD

There has been significant emphasis placed on injury prevention in the military and the Federal government in recent years. The Federal Worker 2000 Presidential Initiative requires a reduction in the overall occurrence of injuries, a reduction in the occurrence of injuries at the highest rate work sites and a reduction in the rate of lost production days for all Federal agencies and departments.

Accurate and timely ergonomic assessments leading to redesigns of the workplace, tools and equipment are essential to facilitate a soldiers' return to full duty status following an injury. However, the shortage of trained ergonomists to conduct assessments have resulted in poorly focused return to duty efforts, frequent re-injuries, eventual increases in hospitalizations and disabilities.

Data on 125 physically demanding, high injury risk tasks were collected by on-site ergonomist and evaluated by them. Data from these same tasks were also collected on-site by technicians and evaluated by off-site ergonomists. The results of the assessments conducted by on site ergonomists and off site ergonomists showed good agreement with the Borg scale, fair agreement was seen with the DOD Level 1 Guides and fair agreement was seen with the NIOSH Lifting Equation. Both the Ovaco Working Posture Analysis System and the Rapid Upper Limb Assessment tool were dependent on the quality of the videotape and

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ABSTRACTS



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PF 101 Agricultural Health and Safety

Papers 1-6

1. RELATIONSHIPS BETWEEN WORK EXPOSURE AND RESPIRATORY OUTCOMES IN POULTRY WORKERS.

S. Kirychuk, J. Dosman, P. Willson, L. Dwernychuk, University of Saskatchewan, Saskatoon, SK, Canada; J. Feddes, A. Senthilselvan, C. Ouellette, University of Alberta, Edmonton, AB, Canada

A pilot study was conducted on 74 poultry barn workers in Western Canada during the winters of 1998-2000. General respiratory health, current, chronic and work related respiratory symptoms; general work duties, and work-site factors were ascertained, pre-exposure, by questionnaire. Personal airborne exposure levels and changes in symptoms and lung function were measured across the work-shift for all workers. Workers were classified according to the type of poultry operation (floor based, n=53; cage based, n=13) in which they worked. There was no significant difference in daily hours spent in the barn between those who worked with caged poultry (5.41±2.35 hours) and those who worked with floor-based poultry (4.42±2.48 hours). Age of birds was 47.10±58.36 days for floor based versus 155.91±63.01 days for cage based facilities.

There were no significant differences in personal environmental measurements between cage-based and floor-based facilities (ammonia 13.22±13.70 ppm, 17.34±16.35 ppm; total dust 5.74±4.85mg/m³, 10.01 ±8.84 mg/m³; endotoxin 6046±6089 EU/m³, 5457±5934 EU/m³ respectively). There were no significant differences in across work-shift change in pulmonary function indices between workers from cage and floor-based operations. For the entire sample total dust dose (work hours/day x total dust) significantly correlated with across-shift change in FEV₁, whereas endotoxin dose and ammonia dose did not. Stocking density was significantly correlated with average ammonia (ppm, p=0.002) and ammonia dose (ppm x work hours/day; p=0.004) in floor based operations and with total dust (particles/ml, p=0.002) in cage based populations. Stocking density was also significantly correlated with chronic cough (p=0.003) and across work-shift cough (p=0.05) and chest tightness (p=0.06) for workers from floor based operations; and with phlegm when working (p=0.018) and chest tightness across the work-shift (p=0.004) for workers from cage based operations. Type of poultry production operation and therefore type of work exposures appear to significantly impact symptoms experienced by workers exposed to these atmospheres.

2. DUST GENERATION SYSTEM FOR AGRICULTURAL SOIL DUST. K. Lee, R. Domingo-Neumann, R. Southard, UC Davis, Davis, CA

Agricultural workers are prone to exposure to mixed dust of inorganic and organic compounds. Diverse working conditions and operations in agriculture make direct measurements of the mixed dust exposure difficult. This study was conducted to develop a new dust generation system to determine possible exposure potency indicators of soil samples. The dust generator consists of a blower, a rotating chamber and a settling chamber. The rotating chamber has inner baffles to provide sufficient agitation of the samples while the chamber is rotating. A blower provides air into the rotating chamber, and the suspended dust is moved to the settling chamber through a perforated pipe. A small fan inside the settling chamber helps maintain suspension of the dust. Various size fractions of dust are sampled on filters suspended in the chamber via outlet ports and attached pumps. Air pressure is released through a filter plate mounted on the wall of the settling chamber. Various operating conditions were evaluated: air intake from blower, speed of rotation, soil mass and sampling time. To evaluate the characteristics of dust from the system, we collected dust samples from agricultural fields while the soil was prepared for